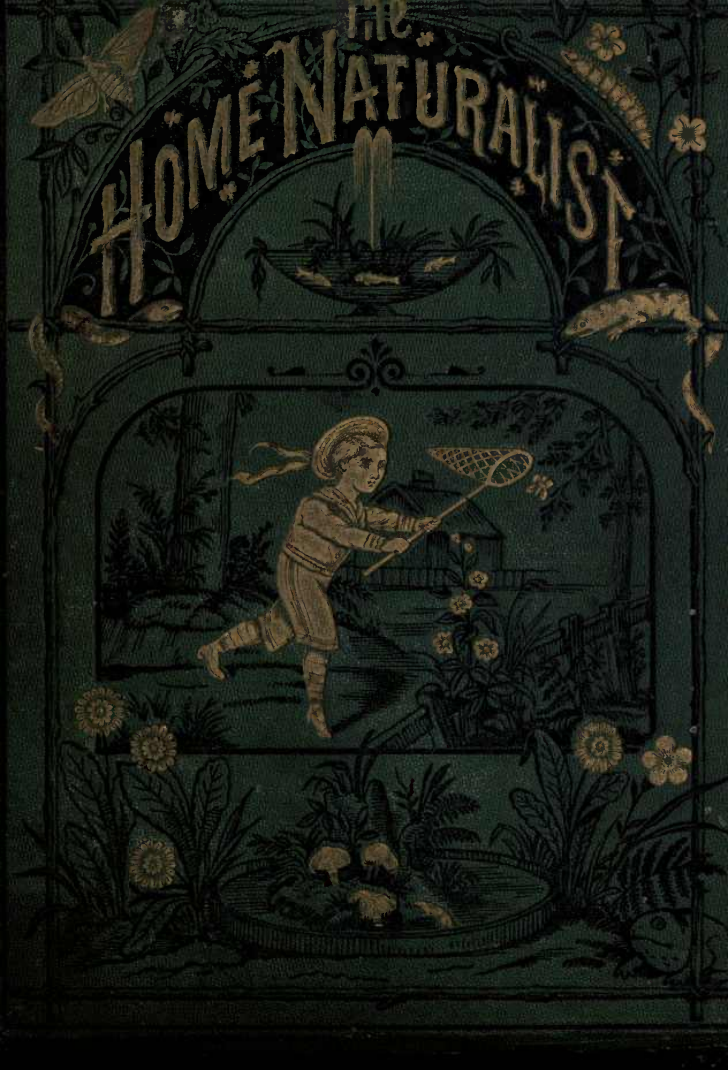
The Home Naturalist





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IN THE WOOD.

1. *Calosoma sycophanta.*
2. *Pimpla varicornis.*
3. *Ichneumon raptorius.*
4. *Sarcophaga albiceps.*
5. *Bombyx monacha.*
6. *Caterpillar of ditto.*
7. *Bombyx monacha, pupa.*
8. *Bombyx processionea.*
9. *Caterpillar of ditto.*

THE HOME NATURALIST;

With Practical Instructions

FOR

COLLECTING, ARRANGING, AND PRESERVING NATURAL OBJECTS.

Chiefly Designed to Assist Amateurs.

BY

HARLAND COULTAS,

Late Lecturer on Botany at the School of Medicine, Charing-Cross Hospital.

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PREFACE.

THE present volume is a free adaptation of a German work, entitled *Das Buch der Sammlungen*, by Otto Klasing (second edition, Leipsic, 1875). The requirements of English collectors have throughout been carefully kept in view; much, therefore, that was chiefly or exclusively suitable for Germany has been omitted. No doubt an expression or reference, here and there, will show the original intention of the book; but it is hoped that this will not render it the less serviceable.

To interest young people in the study of Natural History, teaching them "how to observe," and, especially, how to methodize and arrange the results of their observations, has been the main object both of the Author and of the lamented Translator. The latter, during a life of much feebleness and affliction, was an enthusiastic student of nature, and, no less, a sincere and humble Christian. He could not write, especially for the young, without some distinct reference to the truths of the Gospel; and the lessons of faith and piety scattered by him through these pages derive a touching interest from the fact that the writer has passed into the perfect life above.

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CONTENTS.

SECTION I.

On the Capture of Insects.

PAGE

Beetles 1

Butterflies and Moths 11

SECTION II.

The Caterpillar Collection.

Caterpillar Breeding 15

The Caterpillar House 20

Preparation of the Caterpillar Collection 23

SECTION III.

The Beetle and Butterfly Collection.

Setting-out and Mounting Beetles and Butterflies 26

Preservation and Arrangement of the Collection 29

Order I.—Coleoptera, or Beetles 33

The Classification 37

Order VII.—Lepidoptera, or Butterflies and Moths 48

Classification of Butterflies 49

The Diurnal Lepidoptera, or Butterflies (Diurna) 49

Nocturnal Lepidoptera, or Moths (Nocturna) 52

PAGE

The Lepidarium 59
An Outline Sketch of the Insect Orders 60
Sub-class I.—Insects having a sudden and complete metamorphosis 61
Order IV.—Membrane-winged Insects (Hymenoptera) . . . 61
Order VIII.—Two-winged Insects (Diptera) 68
Sub-class II.—Insects having a gradual and incomplete metamorphosis 73
Order III.—Nerve-winged Insects (Neuroptera) . . . 73
Order II.—Straight-winged Insects (Orthoptera) 74
Order VII.—Half-winged Insects (Hemiptera) 78

SECTION IV.

The Plant Collection.

The Herbarium 82
How to Collect, and Where to Find the Plants . . . 83
On Pressing, Drying, and Mounting Plants 85
How to Name the Plants and Arrange the Herbarium . . 89
Arrangement of Plants according to the Natural System of Botany . 96
The Cryptogamous, or Flowerless Plants 99
I.—The Higher Cryptogams (Vasculares) 100
II.—The Lower Cryptogams (Cellulares) 104
Mosses 104
Liverworts 110
Lichens 111

SECTION V.

The Collection of Woods.

A Wood Collection Recommended 122
How to Recognise the Wood of a Tree 123
How to Prepare the Collection 124
The Needle Woods 127
The Leaf Woods 128

SECTION VI.

The Mineral Collection.

PAGE

The Continual Changes in the Mineral Kingdom 135
What a Mineral Collection should contain 139
Tools used for obtaining Minerals and Fossils 139
How to Preserve the Specimens 140
How to Recognise and Analyse Minerals 140
The Classification of Minerals 144
Saline Minerals 144
Earthy Minerals 146
Metallic Minerals 153
Metals associated with Oxygen 153
Minerals united with Sulphur 156
Minerals associated with Arsenic 159
Pure Metals 159
Combustible Minerals 161

SECTION VII.

The Aquarium.

The Principles on which Aquaria are Constructed 165
Practical Directions for Making an Aquarium 167
The Plants suitable for an Aquarium, and Where to find them . . 168
The Animals suitable for the Aquarium 172
Fresh-water Mollusca 172
The Fish 172
The Reptiles 174
Insects and Larvæ 177
Insect Transformations 183
Fresh-water Crustacea, Polyps, and Infusoria 187
The Management of the Aquarium 189
Animal Life in the Aquarium 190

SECTION VIII.

The Terrarium.

PAGE

The Study of Natural History promotes Health, Longevity, and Religion 196
Practical Difficulties in the Study of Natural History, and how to overcome them 197
Instructions for the Formation of a Terrarium 197
The Animals suitable for a Terrarium, and how to Manage them . 199
Harmless Reptilia 199
Transitional forms between Lizards and Snakes 203
True Reptiles 206

SECTION IX.

The Insectarium.

Origin of the Insectarium 212
How an Insectarium should be Constructed and Regulated . . 214
Caterpillar Breeding in the Insectarium 216
How to Preserve Butterflies in the Insectarium 219
Ichneumon Parasites 219
Insects suitable for the Insectarium 220
Closing Religious Reflections 223



List of Illustrations.

Alum crystal, 145
Antennæ, forms of, 36
Antimony crystal, 158
Apple moss, 107
Apple tree, section of, 131
Aquarium, 165
Argus butterfly, under side and upper side, 29
Ash, section of, 129

Barbula moss, 160
Battle between two salamanders for a worm, 193
Beard lichen, 115
Bee, drone, 68
Bee, queen, 68
Bee, worker, 68
Beech, section of, 130
Bees secreting wax, 67
Beetle and butterfly collection, 26
Beetle, leg of, 36
parts of, 33
Beetles, antennæ of, 36
claws of, 37
Blind-worm swallowing an earth-worm, 204
Blow flies, 72
Blowpipe, 141
Blowpipe analysis, 142
Blue butterfly, 18
Bog moss, 107
Bombardier beetle, 9
Bot fly, 71
Botanist, young, 84
Boxes for minerals, 140
Boxwood, section of, 131
Broom moss, 106
Bulb, thinned, 87
Butterflies, scales of, 48
Butterfly net, 13
Butterfly shears, 13
Butterfly in shears, 13
Beetle sieve, 11

Caddis flies, larvæ of, 74
Capturing insects, 1
Carabus, parts of mouth, 34
Carrion beetle, 5
Caterpillar collection, 15
Caterpillar house, 20
Caterpillar in test-tube, 23
Caterpillar rake, 19
Caterpillars, group of, 25
Catharinea undulata, 105
Cerambyx heros, 46
Chamæleon fly, spiracle, 70
Chestnut, cultivated, 129
Chrysalis, 184
Cicada, 78
Cicada, auger of, 79
Clear-wing moth, 54
Club moss, 103
Cockchafers, 27, 42
Collecting drawers, 32
Collecting net, 3
Cord moss, 107
Corn-weevil, 10
Crane fly, 69
Cross toad, 202
Cup lichens, 114
Curled pondweed, 169
Cushion moss, 107

Death-grip of butterfly, 13
Death-watch beetle, 40
Diving water-beetle, 38
Dragon fly, wings expanded 73
Dragon fly, wings closed, 73

Egyptian sacred beetle, 6
Emperor butterfly, 51
Emperor moth, 21
Endogenous stem, 95
Evacuation of caterpillar, 24
Exogenous stem, 94

Fairy-ring mushroom, 120
Feather mosses, 104
Felspar crystal, 148
Fissidens, 106
Flea beetles, 8
Fountain in aquarium, 166
Fucus vesiculosus, 116

Gamma moth, 56
Garden-pot, net, and larvæ, 20
Garnet crystal, 151
Garnet crystal, white, 147
Geological hammers and chisel, 140
Glow-worms, 10
Gnat, caterpillar, chrysalis, and imago, 69
Goldsmith beetle, 9
Ground beetle, 38
Gypsum crystal, 152

Hawk moth, 53
Heavy spar crystal, 153

Herbarium, 82
Hornet, paper-making, 65
Horse-tail, fronds of, 100
Hydra in search of prey, [188
Hydras, 188

ICHNEUMON flies, 63
Ichneumon fly depositing eggs, 62
Infusoria, 189
Insect box, section of, 31
Insect forceps, 31
Insect transformations, 184
Insectarium, 212, 214
Iron pyrites crystal, 158

LAMINARIA digitata, 117
Land tortoise, 176
Larch, section of, 128
Larvæ feeding on cloth, 58
Leaf frog on ladder, 202
Leaf-rollers, 57
Letter lichen, 112
Lime crystals, 151
Linden, small-leaved, 132
Lizard and spider, 205
Locust, 77

MAY fly, 74
Mineral collection, 135
Mounted beetles, 27
Mounted insect and ticket, [32
Mourning cloak, 17
Mushroom, 120
Musk beetle, 45

NUT-WEEVIL, 11

OAK galls, 64
Oil beetle, 44

PEA-WEEVIL, 11
Pear tree, section of, 130
Pennywort, 171
Peristome of mosses, 106
Plant ticket, 85
Plants, mode of securing, 88
Plum tree, section of, 130
Polypody, fronds of, 101
Polypody, sorus of, 101
Praying mantis, 76
Presses for drying plants, [87
Pupa chest, 21

QUARTZ crystals, 147

RED admiral, 17
Reindeer lichen, 113
Ring-snake swallowing a frog, 208
Ringlet butterfly, 18
Rose-chafer, 42
Rose-leaf-cutter bee and nest, 66
Rose-star moss, 105

SACRED beetle, sculpture of, 41
Salamander, spotted, 200
Salamanders fighting, 193
Saw beetle, 46
Saw-fly, ovipositor of, 61
Scabious butterfly, 50
Scarabeus, 6
Scarlet under-wing moth, [56
Scavenger beetles, 5
Setting-boards for butterflies, 28
Sexton beetle, 4
Silkworm moth, changes of, 23
Silver-washed fritillary, 50
Skeleton of snake, 204
Slabs for mounting, 27
Smooth snake, 207
Snake, skeleton of, 204
Spring beetle, 6
Stag beetles, 7, 43
Stone lichen, 113
Stone oak, section of, 129
Stone pine, section of, 127
Straight-hair moss, 107
Sundew, round-leaved, 171
Surveyor caterpillar, 55
Swallow-tailed butterfly, 16

TAPERING bag, 13
Terrarium, 196, 211
Terrarium, island, 198
Terrarium, tree for, 198
Thistle butterfly, 17
Tiger beetle, 8
Tin box for beetles, 3
Tin crystal, 155
Tree moss, 107
Tree trunk, 123
Tsetse fly, 70

VIPER and smooth snake, [207
Viper, mouth of, 206

WALL lichen, 113
Walnut tree, section of, 133
Wasp, 65
Water beetle and larvæ, 179
Water beetle and stickleback, 192
Water boatman, 182
Water flea, 187
Water milfoil, 170
Water newt, 175
Water plantain, 169
Water scorpion, 181
Water star-grass, 168
Water violet, 170
Water woodlouse, 187
Whirligig beetle, 38
Wood anemone, 85
Wood collection, 122
 a leaf of the, 125
 box for, 125

THE HOME NATURALIST.



Section I.

ON THE CAPTURE OF INSECTS.

BEETLES.

Not without reason have many naturalists placed beetles at the head of the insect world, for they exhibit the greatest variety of form, and in the household of nature occupy all conceivable positions and callings. These insects are called in science Coleoptera (from Gr., *κολεός*, a sheath, and *πτερόν*, a wing), because the true membranous wings with which they fly are transversely folded, when in a state of repose, beneath another pair of protecting wings of a hard and horny texture, called elytra (Gr., *ἔλυτρον*, a covering).

Beetles are the best known and most numerous of all the insect tribes. Their immense numbers, the ease with which they may be

preserved, the metallic brilliancy of some of the species, and the interesting habits of others, their singular forms, and the fact that all are harmless, and may therefore be handled with impunity, have won for them the enthusiasm of the collector and the love of the naturalist.

Coleoptera occur in almost every country capable of supporting animal life. Even the ungenial sun of Greenland and Iceland awakens to a short and precarious existence a few small species, which endure, or rather escape from, the rigours of an arctic winter by a kind of hibernation partly analogous to that of some of the vertebrate animals.

Beetles may be found beneath almost any piece of loose moss-covered wall, under any great stone that has been long undisturbed, the deeper sunk in the soil the better; or beneath the moss and lichen covering the trunks of old trees crumbling into decay: such places, carefully examined, will often prove to be the haunts of rare and beautiful species.

In very early spring, before the snow is melted, and when the rays of the sun fall obliquely, so that the earth is only slightly warmed, beetles are alive and active under stones, on grassy mound and heath, or by the wood and meadow pathway. If the stones are turned over in order to surprise them, these active little animals can soon be seized. No boy sharing the kindly feelings inseparable from a true naturalist will, without good and sufficient reason, deprive any creature, however humble, of its life; for all the handiworks of God enjoy the life and powers He has given them, have their part to perform in nature, and are, to a greater or less extent, useful. A beetle or spider running on the ground, or a bee or butterfly on the wing, in diligent search of the honey or pollen of flowers, seeking the food which its Creator has provided for it, or delighting in the pleasure of its existence, will be allowed to pass unmolested, unless it is really wanted as a specimen for the study or a sample for the cabinet. And even then it is incumbent on the young naturalist to employ all care and skill in the *painless* extinction of life; so as

> "Never to blend his pleasure or his pride
> With sorrow of the meanest thing that feels."
>
> *Wordsworth.*

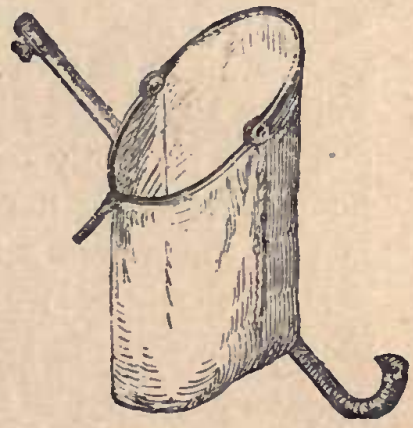
Beetles as soon as taken should be put into a wide-mouthed phial about 2½ inches high and 1½ inch in diameter, containing spirits of wine, and having a cork stopper, which should be secured to the neck of the bottle by a piece of string or twisted wire. A smaller bottle should be used for smaller insects, which are usually killed by the prussic acid given off by bruised laurel leaves placed in the



Great and small Beetle-glass.



Tin Box for Beetles.



Collecting Net.

bottom of the bottle. Sometimes the mouth of the bottle is tightly closed with a cork, through which is passed a quill tube, projecting about an inch below the bottom of the cork. This allows the admission of air when the smaller insects are to be kept alive, and at the same time prevents their escape.

Trees often afford food for beetles, every part of the tree being liable to their attacks. In spring their buds, leaves, and flowers are devoured, and in autumn their fruits. If watched, the woodpecker teaches us where and how beetles are to be found, viz., in the stems of hollow trees; for by his repeated blows on the bark he brings many of them to the surface.

The water has its own peculiar species of Coleoptera,—great and small varieties swimming on the surface or diving below it. After sunset, water-beetles will come to the surface, attracted by the light of a lamp, or even leave the water and fly around it. Small ponds and pools filled with an abundance of water-plants are usually the haunts of different kinds of aquatic beetles, which are

easily taken with a dip-net, and are all deserving a place in every collection.

The nets required for catching insects are few, simple, and easily made. The wood-cut on page 3 represents a net commonly used in Germany for the capture of beetles, which is strongly recommended. It consists of a simple sack, made of strong, light linen or cotton, which is sewn over a jointed iron hoop, like a butterfly-net, having a depth equal to twice its diameter. The bottom of a strong walking-stick is provided with a hollow joint, into the thread of which a short screw projecting from the hoop tightly fits. The net can thus be firmly screwed on to the end of the stick. When the hoop is folded at the joint, the mouth of the net is closed. When in use, the net is held open-mouthed under the bushes which are beaten, the insects or larvæ falling into it. The net may also be used to sweep the grass and flowers. When done with, the net is unscrewed from the end of the stick and folded, and both net and stick are easily carried home.

All beetles produce eggs, and undergo a perfect transformation or metamorphosis. From the egg comes a soft-bodied grub or maggot, with a horny head and jaws. The grub in a shorter or longer time changes into a chrysalis, out of which emerges the perfect beetle.

Some beetles appear to have been created expressly to consume unhealthy organized matter, or to effect its removal. Among the beetles thus usefully employed is the sexton beetle (*Necrophorus*, Gr., *νεκρός*, dead; and *φέρω*, to bear), of which several species are found both in England and North America. These beetles have the remarkable habit of burying the dead body of any small animal which they may meet,—such as a mouse, mole, frog, lizard, or bird. When the carcase is thus interred, the female lays her eggs in it; these are quickly hatched into grubs, which, as soon as they become perfect insects, pierce the ground and come forth.



Sexton Beetle.

The *Silphidæ* (Gr., *σίλφη*) is another group of carrion-beetles which employ themselves in this manner. This genus is easily known by

its wide, depressed, and somewhat flattened form of body and wing sheaths. The silphides quickly congregate around putrescent animal matter, so that wherever the carcase of an animal is decaying, or even a bone is not perfectly bleached, we may find them at work, performing their part as scavengers, destroying and removing the carrion, which would otherwise poison the atmosphere.



Carrion Beetle.

In the creation of large numbers of scavenger-beetles, we see the provision God has made for preventing the impurity of the air, which would impair the health of man and other animals. Those insects which some persons look upon as ugly, and as engaged in what is disgusting, are really doing a good work. Acting according to the instinct God has given them, they are fulfilling a most useful purpose, showing that nothing in nature is to be regarded with contempt and abhorrence; and showing, too, that the Creator of all things cares for the health and welfare of His creatures.

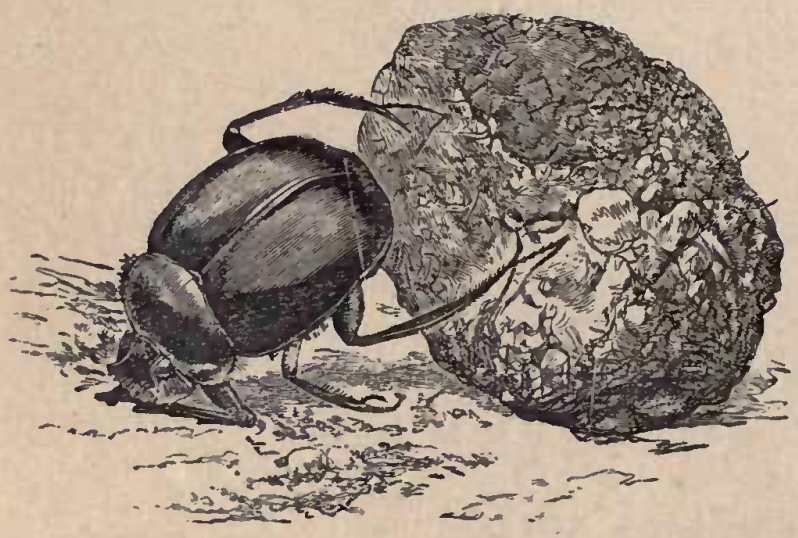
To another class of scavenger-beetles appears to have been allotted the task of burying offensive animal deposits. Some convey the dung to the bottom of holes dug to receive it, and place their eggs in the midst of the heap thus accumulated, leaving their offspring surrounded by a plentiful supply of food. Such are the common *Geotrupes* (Gr., γῆ, earth; τρυπάω, to bore). This dung-beetle is common in pastures, making its abode near the fresh excrement of the cow, which it lowers into a hole about a foot in depth. The hills made in the excavating process may usually be seen near the manure. Other kinds of dung-beetles live in the midst of the droppings of cattle, which they consume for food; one of these is the *Aphodinus*, a small beetle with black head and thorax and red elytra, or wing-covers, found commonly in horse-dung. These small beetles, continually living in the midst of



Scavenger Beetles.

the dung, and feeding upon it, perforate the mass with holes in all directions, and thus make it pervious to the air and wind, by which it is soon dried and scattered.

The most remarkable of the dung-beetles is the *Scarabæus sacer*, the sacred beetle of the Egyptians, which was an object of superstitious worship, and which was figured on their monuments and ancient sarcophagi. Dung-beetles are common in America and England, and are models of industry and parental care, being continually occupied in making balls of fresh manure mixed with earth, about the size of a common marble, in which they deposit an egg. After making a hole two or three feet deep in a convenient place, as soon as the ball is dry, they roll it with their hind legs into the hole, burying the offspring which has been the object of so much care. Upon the dung thus deposited the larvæ, when they are hatched, feed. It appears that the instinct of these beetles does not enable them to distinguish their own ball, as, if they lose it, they seize upon that belonging to another. It is also quite common to see several of these beetles assisting each other in rolling the same ball.



Egyptian Sacred Beetle.

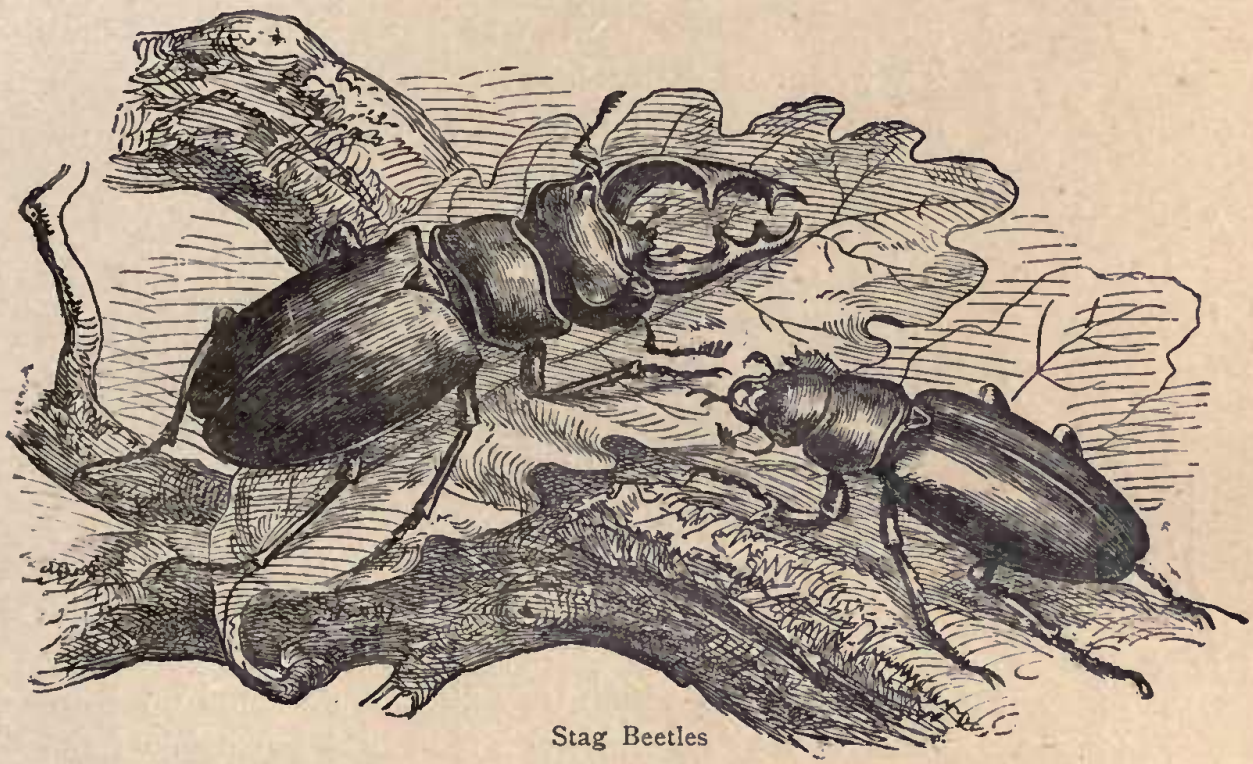


Spring Beetle.

The leading characteristic of the spring beetles, *Elateridæ* (Gr., ἐλατήρ, a driver), is their remarkable power, when laid upon their backs, of immediately reversing their position, and alighting on their feet. Hence their scientific name, which refers to the driving or impelling force by which this is accomplished. The larvæ of these *Elateridæ* are called wire-worms, and are often very destructive to the root crops of the farmer; but, although they may

occasionally do harm, as they live chiefly on the wood of decaying trees, which they thus help to destroy and reduce to dust after they have passed their prime, they must be considered on the whole as serviceable insects.

The largest of the British Coleoptera is the stag-beetle (*Lucanidæ*), the larva of which lives for several years burrowing in the wood of



Stag Beetles

the oak; afterwards, when in the beetle form, flying about the tree on summer evenings, and settling down occasionally on the trunk and branches.

At all seasons decayed wood is a favourite haunt for the larvæ of beetles, and is therefore an object of interest to young entomologists. In searching the woods for Coleoptera, not only should old logs be rolled over to uncover the beetles lurking beneath them, but also, if practicable, they should be knocked to pieces, for the perforations in the wood indicate the presence of larvæ, and they are therefore worth examination.

Many different varieties of Coleoptera may be found in such fungi as *Agarici* (mushrooms), *Boleti* (toadstools), and dry-rot, plants of

very little use to man, many of them poisonous, and very offensive when in a state of decay; beetles are very useful in removing these substances.

The entomologist will find in gardens in the spring of the year the flea-beetle (*Haltica*), so called from its size and its habit of leaping. These insects feed on the leaves of the radish, horse-radish, turnip, cabbage, and other cruciferous plants, which they very often injure. They conceal themselves during winter in dry places, under stones, and in chinks of walls, in the spring laying their eggs upon the leaves of the plants on which they feed.



Flea Beetle.

During the spring the harmless lady-bird (*Coccinella*) may be frequently observed. The species are usually distinguished by the colour and spots of their wings. Both in their larval and perfect state the ladybird-beetles are usefully employed in greedily devouring the aphides, or plant-lice, which infest the leaves of plants.



Lady-bird.

In summer, tiger-beetles (*Cicindelidæ*) are found flying in the hot sunshine, and occasionally alighting on the pathway. They are carnivorous, subsisting wholly on other insects, to which they give chase either on wing or on foot. The most common and beautiful of the English species is the green tiger-beetle (*Cicindela campestris*), the head, thorax, and elytra of which has a beautiful golden green metallic lustre; there are five small white spots on the elytra, and the legs are long and slender, enabling it to run rapidly as soon as it alights upon the ground. It has a white labium or upper lip, and a pair of powerful jaws crossing each other horizontally. Its large prominent eyes give it great accuracy of vision, so that when it takes its flying leaps it invariably alights on the insects aimed at. It instantly tears them in pieces and devours them. This beetle is an admirable type of the family to which it belongs, which are the most predaceous of the Coleoptera.



Tiger Beetle.

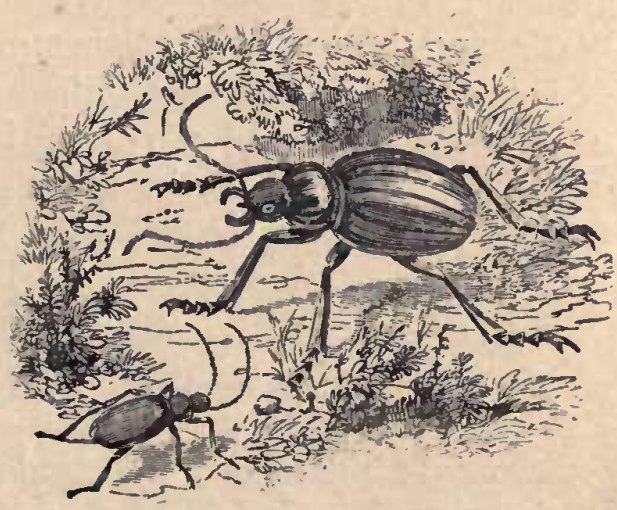
The larva of this insect lives in cylindrical holes in the ground, excavated by itself, varying from six inches to a foot in depth. It is a whitish grub, with a large flat metallic-looking head, and two hooked tubercles on the eighth segment of the body. These tubercles enable the creature to fix itself firmly to the inner walls of its burrow, at such a height that its head exactly occupies and closes the mouth of its hole. Here it lies in wait for its prey, generally some other insect or larva, which it seizes with the greatest ferocity, carrying it off in its powerful jaws. The larva of the tiger-beetle may be easily taken by thrusting a piece of straw down its hole, which the larva will try to push out again ; in doing this it will come to the surface, and is then easily captured, as it clings to the straw.

The ground beetles (*Carabidæ*) belong to another group of very common carnivorous beetles, and are easily known by their rapid movements on the ground and their metallic lustre. The *Carabus auratus*, or goldsmith beetle, will often be noticed, especially in summer, when they most abound, attracting attention by their activity, energy, and brilliant hues. This family, as well as that of the Cicindelidæ, are very useful, and deserve encouragement both from farmers and gardeners, as they capture and extirpate other insects, especially those that feed upon vegetables, and are therefore hurtful to the crops. The bodies of the Carabidæ are particularly hard and firm, enabling them to sustain the weight of the heavy stones, under which they frequently run in search of other beetles and larvæ.



Goldsmith Beetle.

Another most remarkable species is the bombardier beetle, or *Brachinus crepitans*, which is found under stones in



Bombardier Beetle.

damp and grassy places. It derives its name from a peculiar discharge, which, when irritated, the creature rapidly ejects, with an audible noise. This discharge is an acrid fluid having a penetrating odour. It thus checks the pursuit of the carabus or other insect which is in chase of it, enabling it frequently to escape. The insect fires its artillery as soon as it is touched, and the collector is usually not a little surprised and startled at such an unexpected phenomenon, the report being somewhat loud, considering that the insect is only about half an inch in length.

On sultry summer evenings, more especially after thunder-showers, in shady lanes, on grassy banks, and in woodlands, the glow-worm (*Lampyris noctiluca*) is to be seen exhibiting its beautiful greenish phosphorescent light amongst the grass. It is not yet decided by entomologists whether the male glow-worm is luminous at all, but it is universally agreed that, if it be so, it is only in a very slight degree. The light proceeds from the last segment of the abdomen. The male is provided with wings, and flies freely; the female is apterous, or wingless, and her luminosity is intended to attract her companion. The light can be varied or suspended at the pleasure of the insect; it may be increased by placing the creature in warm water, but is extinguished by cold water. The acrid discharge of the bombardier beetle, and the brilliant radiance of the glow-worm, are both proofs of God's provision for the welfare of His lowlier creatures.



Glow-worm (male and female).

In autumn those beetles which feed upon the fruits of the season make their appearance; amongst these is the weevil tribe (*Curculionidæ*); the corn-weevil (*Calandra granaria*) destroying the corn, the pea-weevil (*Bruchus pisi*) peas, and the nut-weevil (*Balaninus nucum*) nuts. The last beetle is furnished with a long slender rostrum or snout. Its larvæ or grubs are commonly found in nuts. The egg is deposited in the nut whilst it is young and soft; therefore the wound soon heals, and the nut continues to grow and ripen. The larva, which



Corn Weevil.

is hatched in a fortnight, feeds upon the kernel, and ultimately escapes through the shell, leaving a small round opening. This occurs in September, when the nut has dropped to the ground. The grub changes into a pupa, and remains in that state until the following summer, when it comes forth a perfect insect. During autumn, small weevils may also be observed laying their eggs in the bloom-buds of apple and plum trees. In the spring the grubs are hatched, and feed on the petals, destroying the bloom; they then descend to the ground, and pass into the chrysalis state. In autumn they assume their beetle-life, and in their turn injure the bloom-buds of the following year.

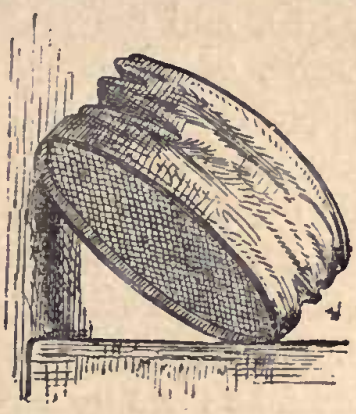


Pea-Weevil.



Nut-Weevil.

In autumn, as also on dry, frosty winter days, which are free from snow, leaf-mould from under groves and thickets should be sifted with a beetle-sieve over a white cloth or a sheet of paper. In addition to beetles, millepedes, or thousand-legs—which are allied to the centipedes of warm climates, but are perfectly harmless in this country—as well as wood-lice (*Oniscidæ*), will remain in the sieve. The beetle-sieve is large, flat, and circular, the upper edge being secured by an iron ring; the sides of the box are made of linen or cotton, and its bottom is formed of fine wire.



Beetle Sieve.

Few insects are stirring during winter; nevertheless, in the months of January and February, pupæ may be found by digging at the roots of trees.

BUTTERFLIES AND MOTHS.

Most butterflies and moths are abroad in the months of June and July, although individual species may be taken from February, if circumstances are favourable, and as late as the month of November.

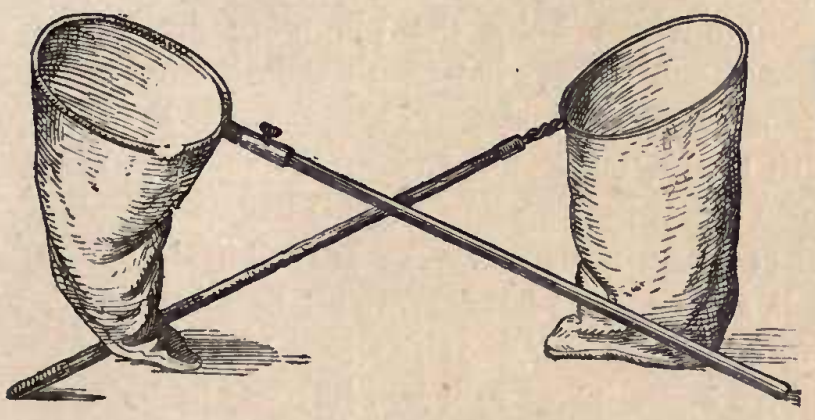
On still, calm days these insects appear in woodlands, flowering meadows, and clover fields; or flying downward, visit valleys abounding in springs and bushes; or rising upward, career away over barren heaths and mountain sides, whilst life is fresh, enjoyable, and in its spring; glad in their life, and gladdening the eye and heart of man, for whom the Creator has provided such varied sources of pleasure.

The butterfly and moth hunter must try at all hours for captures: in the morning or evening twilight, for many beautiful and delicate moths, then awake and active, are not to be taken at any other time; or during the day, for then the butterflies are the most common, especially at noon, when the sun is highest and brightest; or, finally, at night, for then if the air is tranquil and the weather warm, moths may be attracted, even from some distance, by the light of a candle in a room, there to be captured. Or boys may resort to various flowers at night, such as the sallow, ivy, and honeysuckle in their season; and, as the year advances, the French marigold, fuschia, lobelia, and different varieties of the great natural order of compositæ, or compound flowers; for all will be found to be much frequented by moths at night. Moths are sometimes lured by sweet-tasted food, as honey or sugar diluted with water, about which they will fly, and on which they will settle down.

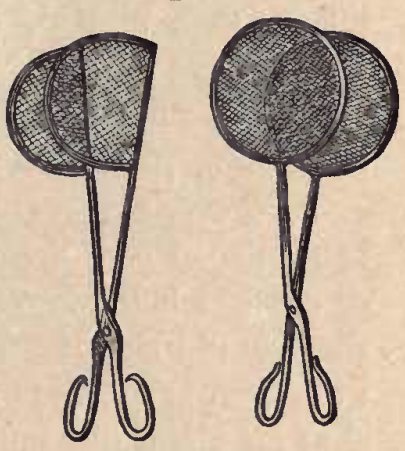
Early in the morning bushes may be beaten with a club, or fruit-trees may be violently shaken over an umbrella; and caterpillars in abundance will fall into it. Pick them up, put them into tin boxes, and take them home.

If a butterfly or moth is on the wing, and promises to settle near you, it must be approached with the net as quietly as possible, taking care that your shadow is behind; for its great eyes are observant of every motion, and if it descries you it will change its position or fly off. Supposing, however, that the object of your chase has at last settled upon a flower, it is easily captured with the butterfly shears, which it is only necessary to open, and then close instantly over the insect, and you have your prisoner secured between the two shallow sieve-like bags of green muslin sewn around the iron rings of your shears.

Another mode of capture is by the common bag-net, or by one which tapers to a point. Both kinds are represented. In either case the length of the net should be double the diameter of the ring at its mouth. The net is stitched around a circular hoop of cane or



Butterfly Net and Tapering Bag.



Butterfly Shears.

wire; this is screwed to the top of your walking-stick, and the implement is complete. These nets can be bought at any shop in London where insects are sold, and where also you can obtain suitable pins with which to fasten your butterflies.

When the butterfly is in the net, it may be instantaneously killed by simple pressure of the thorax (that part of the body to which the



Death-grip of the Butterfly.



Placing the Butterfly in the Shears.

wings are attached) between the thumb and fore-finger. The pinching of the thorax should be immediate and thorough, that the creature may suffer as little as possible; for, we repeat, any

approach to cruelty to the smallest of God's creatures is avoided by a true student of nature. The butterfly is then transferred from the net to the shears, where its wings are laid out flat, and a pin is passed perpendicularly through the centre of the thorax. The insect, thus pinned, is placed in the collecting box. This must always have a cork bottom, which holds the pin more firmly than wood. Butterfly hunters should always have with them a pincushion containing plenty of pins of suitable size.

To prevent any return to life, butterflies and moths should always have placed with them in the collecting box a small bag of camphor, or crushed laurel-leaves (*Cerasus lauro-cerasus*). If the latter be used, they should be cut small, and crushed between two stones, when they will give out exhalations of prussic acid. If the box be kept closely shut for about five minutes every insect in it will become lifeless.

It is difficult to kill large moths. A frequent way is to enclose the moth in a small tin box, and plunge the whole into boiling water; and this is perhaps the best plan, being both speedy and effective.

Our collection of moths and butterflies will not be complete unless we have samples of each insect in its egg, caterpillar, and pupa or chrysalis state. Where to find the eggs and pupæ, and how to breed the caterpillars, will furnish matter for future consideration.

Pupæ are to be found in the most varying circumstances and places, and at all seasons of the year. Sometimes they may be met with hanging freely from the stems of trees and from walls, or on the ground—naked or enveloped in a cocoon; especially may they be looked for at the foot of trees which stand in open places. The pupæ of moths are found on and in the earth, often in the neighbourhood of the plants on which the caterpillars have last lived; sometimes in holes under moss, or under a stone or piece of wood. Decayed branches often contain caterpillars or pupæ. The pupa-hunter will therefore deem no place unsuitable for his search.



Section II.

The Caterpillar Collection.

CATERPILLAR BREEDING.

The study of this phase of insect life is in many respects both attractive and instructive. We observe the growth and development of the caterpillar, its various changes of form, the growth and renewal of its skin; we feel deeply interested in cherishing its life, and rejoice in its welfare throughout the several stages of its progress.

In order to secure the growth of healthy pupæ or cocoons, and the production from them of perfect moths and butterflies, we must supply the caterpillars from time to time with an abundance of fresh air, moisture, warmth, and proper food. These demands are of the utmost importance in the feeding and tending of caterpillars.

Now it is obvious that, to commence aright, we must begin with the eggs of the butterfly, and the place where they were first deposited; and this brings us to the consideration of the food of the larva, as soon as it emerges from the egg. That an unerring instinct should guide the butterfly in selecting the plant best adapted for the nourishment of the caterpillar as soon as it comes out of its shell,

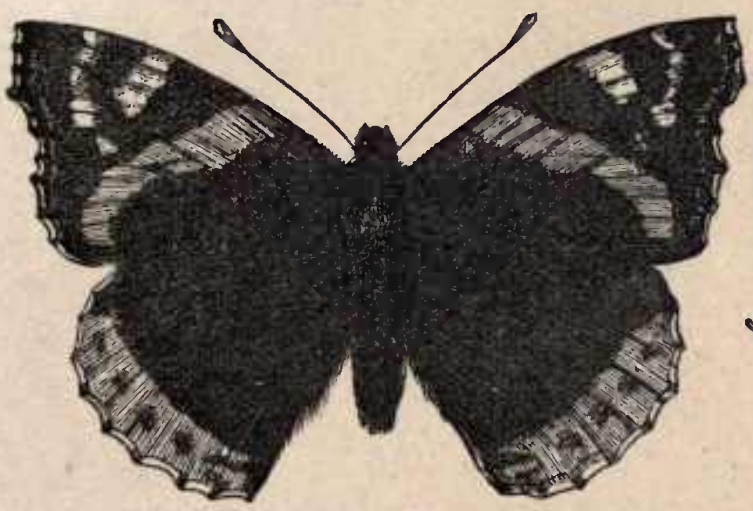
is a most remarkable fact. It is a proof of the wisdom and goodness of the great Creator. That a butterfly should select one, and only one, out of all the shrubs and trees of the field and forest, on which to deposit its eggs, is indeed wonderful. How does it know one plant from another? How does it know that the leaves of the plant selected will afford suitable nourishment for the creature that is to come into existence months afterwards? Whence does it derive its marvellous instinct, but from its All-wise and Almighty Creator? And what increases our wonder and admiration is that each species makes its own selection, and that God has so created all things that they correspond with each other, and that one object in nature is adapted to the wants of another—the leaf of a shrub to the young caterpillar. Thus, in a coppice crowded with every variety of shrub, the emperor (*Apatura Iris*, or *Ilia*) selects the sallow, the white admiral (*Papilio Camilla*) the honeysuckle, and the brimstone butterfly (*Gonepteryx rhamni*) the buckthorn.

The eggs of the swallow-tailed butterfly (*Papilio machaon*) are laid upon the dill and carrot, and those of the Apollo butterfly (*Papilio Apollo*) on the leaves of the orpine. As is well known, the silkworm-moth (*Bombyx mori*) lays its eggs on the leaves of the mulberry-tree, upon which the caterpillars feed. The magpie-moth (*Abraxas grossulariata*) selects for the residence of its larvæ gooseberry-bushes, which they often almost entirely strip of their leaves. The caterpillars of the red-admiral (*Vanessa Atalanta*), and the thistle-butterfly (*Cynthia cardui*), feed on the thistle; and that of the mourning-cloak

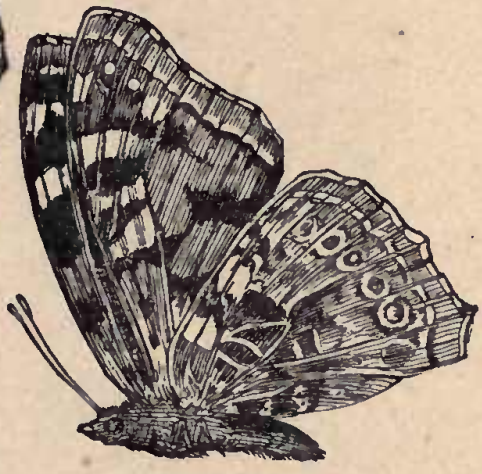


Swallow-tailed Butterfly.

(*Vanessa Antiopa*) on the birch and willow. The larvæ of the death's-head moth (*Acherontia atropos*) are nourished by the leaves of the potato; and those of the oak-lappet moth (*Gastropacha quercifolia*) feeds upon the oak. The larvæ of the cabbage butterflies (*Pontia Brassicæ* and *Rapæ*) often do much injury to those garden vegetables; and those of the hawk-moth (*Sphinx convolvuli*) injure the vine. The caterpillars of the codling-moth (*Tortricidæ*), or leaf-rollers, are the most destructive enemies of the apple crop. The larvæ of the common blue butterfly (*Lycæna*) feed on the rest-harrow, of the orange-tip (*Pontia cardamines*), on hedge-garlic and ladies' smock, and of the ringlet butterfly (*Hipparchia*) on various species of grass. The small copper butterfly (*Polyommatus Phlæas*) lays its eggs on the sour dock or sorrel; and, lastly, the caterpillar of the silver-spotted fritillary (*Argynnis adippe*) feeds on the leaves of the various species



Red Admiral.



Thistle Butterfly.



Mourning Cloak.

of violet, especially the dog-violet (*Viola canina*). The marbled white butterfly (*Melanagria callithea*) must be regarded as a remarkable exception to the usual rule of butterflies providing suitable food



Common Blue Butterfly.



Ringlet Butterfly.

for their offspring; for she drops her eggs at random, as if well aware that the young caterpillars will, as soon as hatched, crawl up some blade of grass in the neighbourhood, and there find suitable food.

The eggs of the butterfly or moth, when first deposited, are always covered with a coat of varnish, which serves the double purpose of fastening them to the leaf and protecting them from the weather. Sometimes the eggs are of a peculiar shape and colour, and laid in a regular manner on the twig or bark of a tree. This regularity is generally adopted by the purple hairstreak (*Thecla quercus*).

When the eggs are hatched, the caterpillars should be swept with a quill feather into an appropriate receptacle, to be presently described, called the "Caterpillar House," where their appropriate food should be provided.

When going out to collect caterpillars, several of the perforated paper-boxes already described should be taken, to bring home the prisoners separately, as there may be among them some who would kill and devour the others like cannibals.

In the early days of spring, some of the most beautiful of the British moths and butterflies, such as the tiger-moth (*Arctia caja*), the tortoise-shell, red admiral, and peacock butterflies, which hibernate under moss, old leaves, stones, and roots, sometimes make their appearance, if the weather become mild; and many more will be disturbed in their winter haunts if the caterpillar-

rake be employed, and the ground well examined. Those days are the most prolific in specimens on which there has been just sufficient warmth to disturb their torpor, while the weather continues sufficiently stormy, cold, and unsettled to intimidate them. The increasing warmth of spring soon lures them upwards, and they may be found in the crevices of bark, and hiding in sheltered situations among the branches.



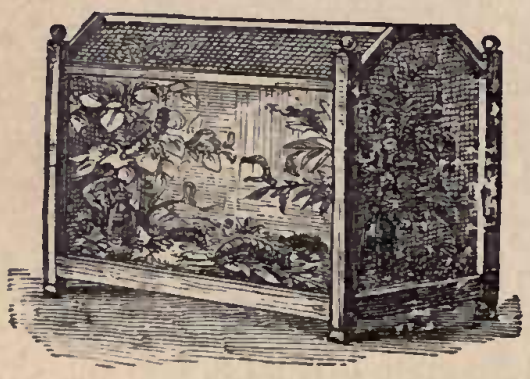
Caterpillar Rake.

The tiger-moth lays its eggs in autumn. The caterpillars are hatched the same month; and after remaining for two weeks in the larval state, and attaining a length of about three quarters of an inch, they retire into winter quarters. In the spring they reappear, feeding on the leaves of the daisy and hollyhock. In June the hairy caterpillar, which is known as the woolly-bear, is feeding in every garden and on almost every plant. Some precaution is necessary in handling it, for the fine points in which the hairs terminate break off, and remain in the skin between the fingers, producing an intolerable itching. In July the creature loses its hairy coat, and becomes a smooth, black, shining chrysalis; the moth emerges from this last state during the same month.

Caterpillars, like moths, may be hunted and captured after nightfall by lamp-light; indeed, this is the only time in which some are abroad and active, as during the day they rest, hiding away as much as possible from observation. It is a matter of common observation that the leaves of certain plants are devoured by unseen insects. We trace their operations day after day, and are unable to solve the mystery, as, after careful examination of the plants, no trace of them is seen. But if we resort to the plants at night, we find the caterpillars have revisited their feeding ground, have availed themselves of the darkness, and are now devouring the plants voraciously. To obtain further information, therefore, as to the life and habits of such mischievous and destructive nocturnal caterpillars, it becomes desirable to have a caterpillar house, where these and other larvæ can be confined, properly fed, and the peculiarities of their metamorphoses noticed.

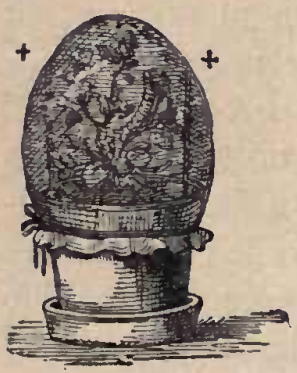
THE CATERPILLAR HOUSE.

This consists of a rectangular case, whose sides and sloping roof are formed of a network of wires crossing each other at right angles, so as to admit of thorough ventilation, and having the front of glass, to allow a complete view of all parts of the interior. Wire-work is necessary for the roof and sides, as wooden lattice-work would be speedily gnawed through by the larvæ. The bottom of the enclosure is of wood, which is covered to the depth of three inches with a mixture of sand and fine garden mould, kept moist by occasional sprinklings with water. For particular varieties, as the emperor-moth (*Saturnia pavonia*), pots in which the plants suitable for their food are grown are placed within the enclosure.



Caterpillar House.

A cheap and excellent larva-house may be made as follows: Fill a common garden-pot with mould, and bend a couple of canes over each other at right angles, pushing the ends of the canes down by the sides of the pot into the mould. Over the support thus formed spread a thin gauze net, fastened firmly to the upper rim of the pot with a fine cord. The illustration is a garden-pot containing plant and larvæ, with gauze-net tied down; this net is made to bulge out with two little sticks. The dome cover made by the arched canes is the better plan, however; this is shown in the garden-pot behind the boy in the cut at the head of this section.

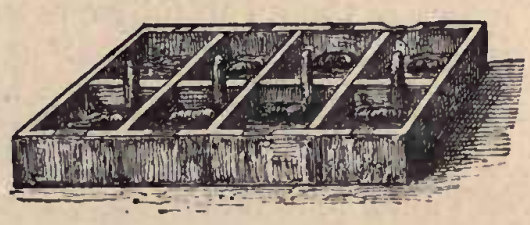


Garden Pot, Net, and Larvæ.

To keep the plants in the caterpillar house green and fresh, as in a state of nature, they must be placed in vases of spring water, which will save the trouble of their daily renewal. Caterpillars prefer to eat the leaves from off the branches to feeding on torn-off leaves. When

the foliage is eaten, fresh branches must be furnished. The principal conditions of success are cleanliness and fresh air. The dirt made by the larvæ should be daily removed with a brush. The house should be kept in a cheerful but not too sunny situation.

When the caterpillars become irregular in their eating, or cease entirely to eat, changing colour and appearance, it indicates that they are about to pass into the pupa state; and the larvæ should be at once placed in the pupa-chest. This is a box made of rough unplaned boards, or with the inside lined with bark. The interior of the box is purposely made rough, to assist the butterfly in creeping out of its pupa case, and afterwards in rising and unfolding its wings. The box is divided into several compartments, each of which is numbered and labelled with the name of the pupa. In the partition wall between each compartment there is a rough upright post, up which the new-born insect climbs as soon as it is out of the chrysalis, and stretches and airs its wings, which, without such a convenience, would be dwarfed and crumpled. Those that become pupæ in the flower-pot should be allowed to remain there during winter, as they do not suffer from the cold, however severe. The pupæ in the box should be also kept in a cold room; because even a slight degree of warmth threatens the health of the pupa, by causing it to become dry.



Pupa Chest.

The first appearance of the butterfly is indicated by a change of colour in the pupa, beginning at the head. At last the long-expected spectacle of a splendidly-coloured butterfly, emerging out of an unsightly pupa as out of a coffin, and in a short time elevating its drooping wings, and committing itself for the first time to the atmosphere, richly rewards all toil and trouble. The emperor-moth, emerging from its pupa case, is here shown, drawn from nature, life size. And a splendid, uninjured specimen may be thus obtained for the collection.



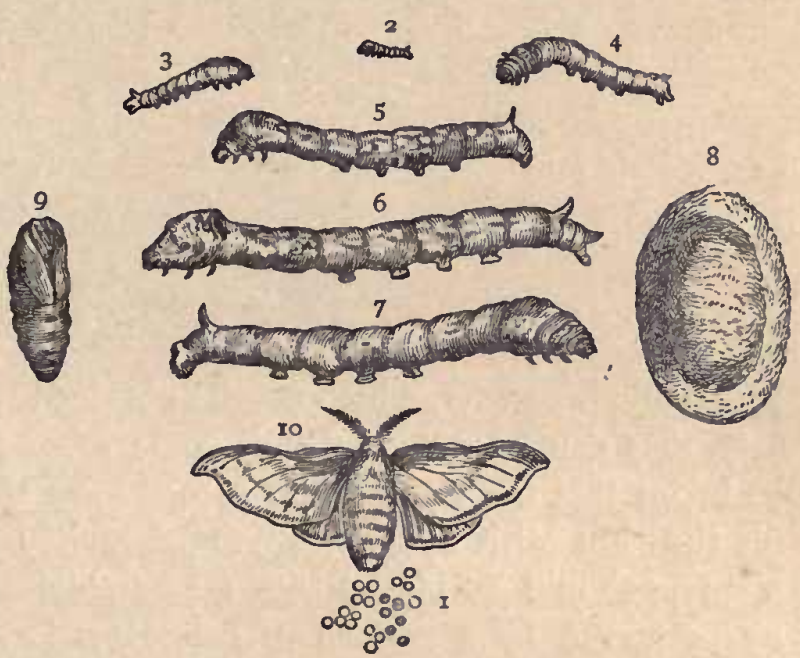
Emperor-Moth emerging from its Pupa Case.

But we may be disappointed. The pupa may become dry or mouldy; or, instead of a butterfly, it may produce only a wasp-like animal, or a brood of ichneumon-flies, whose eggs were laid in the body of the caterpillar, and afterwards developed into footless grubs or parasitic larvæ, at the expense of its fatty parts. The larvæ thus introduced devour the inside of the caterpillar without attacking any essentially vital part, but ultimately ensure its destruction. The life of the caterpillar thus infested appears to be prolonged for the benefit of these parasites; and it sometimes even acquires the pupa form before any signs of its internal enemies become perceptible. Collectors of butterflies and moths are often grievously annoyed in this manner, their carefully preserved pupa producing nothing but the swarming progeny of cuckoo-flies, which have introduced their eggs into the bodies of the caterpillars by piercing them with their ovipositors.

These ichneumon-flies, however, render good service to farmers and gardeners, by destroying the voracious caterpillar which does so much injury to the crops. This is another illustration of the wise arrangement of God, that what is insignificant may be useful, and that what is apparently destructive may really serve some good purpose. The flies belong to the order of hymenopterous insects, as may be seen by a glance at the structure of the four membranous wings; and they have an ovipositor instead of a sting at the extremity of the abdomen, which is pedunculated, or attached to the thorax by a slender and thread-like fleshy tube. They are easily distinguished by their active habits, as they are continually flying about and alighting on the leaves and stems of plants, over which they run with considerable agility, stopping frequently, while their antennæ are in a state of continual vibration. They feed solely on the juices of flowers, and are in constant search of the two great objects of their existence—food and caterpillars.

PREPARATION OF THE CATERPILLAR COLLECTION.

A PERFECT collection of moths and butterflies should contain a sample of each insect in the egg, larva, pupa, and imago, or perfected stage of transformation. Our space does not admit the attainment of this object in every case; it is sufficient to have before us one typical form of these most remarkable transformations, which will be sufficient to show that there are different disguises of one individual. For this object we select one well-known species—the silkworm-moth—and show it in all its stages of progressive development, from the egg to the mature insect.



Changes of the Silkworm Moth. 1, Eggs; 2, 3, 4, 5, 6, and 7, Caterpillar in different stages of growth; 8, Cocoon; 9, Pupa; 10, Moth, or Perfected Insect.

The eggs are fastened to a card with gum. The cocoon is mounted in the same manner. The pupa is first killed in spirits, afterwards well dried, and then fastened with a pin next to the imago or moth. To prepare the caterpillar is neither agreeable nor easy; but exercise and patience ultimately lead to success; and the trouble taken in the preparation will be found to have been well expended. The caterpillar destined to this fate should be kept the previous day without food. The caterpillar is first killed by being placed in an empty test-tube, which is then corked, and immediately plunged into a vessel of boiling water.



Caterpillar in Test-tube.

Tender and thin-skinned caterpillars should be suffocated in olive

oil. If killed in diluted spirits of wine, they should not be left in it long, otherwise all their colours will be destroyed. Caterpillars may be drowned in water without injury to the preparation, but the practice is cruel, and should therefore be avoided.

Lay the larva, as soon as killed, between two sheets of blotting-paper; and having opened it at the end with a penknife, press the contents through the outlet. The greatest caution must be used in applying pressure to avoid injuring or tearing the skin. The evacuation may be helped by a pair of forceps. The emptied skin must be soaked in water or spirit for a few minutes; it should then be taken out, warmed, blown out, and turned till perfectly dry.



Evacuation of Contents of Caterpillar.

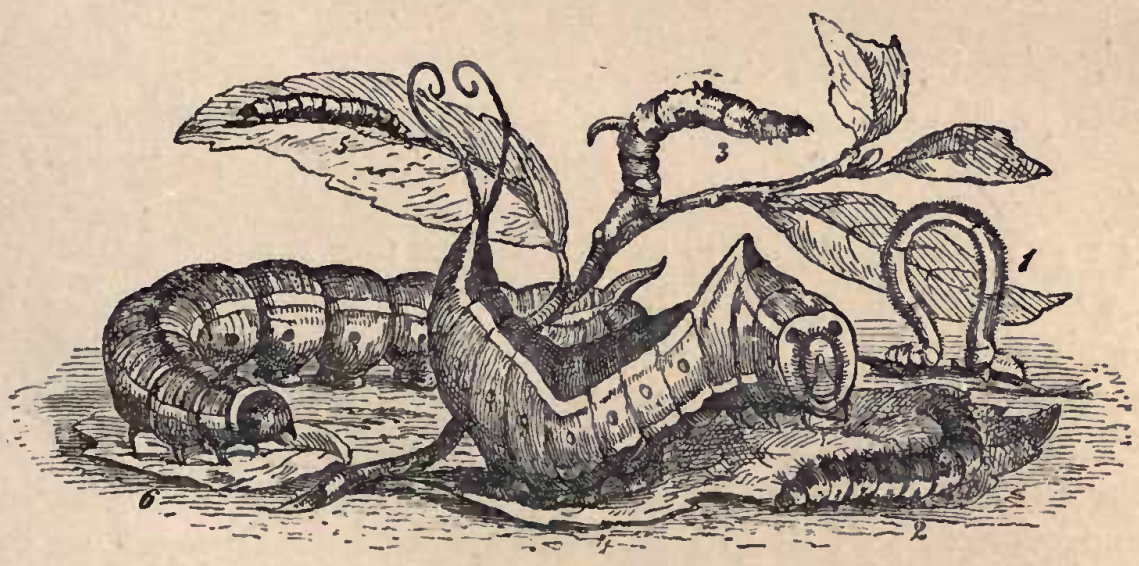
Blown-out and dried caterpillar-skins are very fragile, however. In order to make them stronger, they may be filled with hycopodium powder, which can be obtained from chemists; if necessary, they can be coloured with some other powder; but care must be taken that the air does not escape from the inflated skin. Many fill the skin with a composition of melted tallow and wax. The opening should be closed with gum-arabic. Stuffed caterpillars can be preserved by a varnish of colourless lac.

To secure an appearance which is true to nature is not an easy task, but is the result of much close and patient observation. We cannot have anything better than a living model, and must therefore provide ourselves with the branches and leaves of the plant on which the caterpillar lives; because, if it is to look natural when stuffed, it must be exhibited in a natural posture on the branches and leaves.

The box containing such a group of caterpillars should be rectangular, from four to six inches in depth, and of an area proportionate to the number of caterpillars to be preserved. It should have a glass cover, and the bottom must have an earthy colour; this may be produced by sprinkling earth, saw-dust, and similar matters over a liberal coating of gum. The bodies of the caterpillars must be taken

while they are yet flexible and soft, and bent carefully until their natural curves and position are secured. This is a difficult task, and the skill necessary to accomplish it can only be acquired by practice. If the whole arrangement is so far successful, all other defects may be covered artistically and concealed. The caterpillars should be fastened on to branches and foliage by means of gum or shellac. If the work is properly done, the caterpillars will deceive the spectator into the belief that they are living insects.

The curved form of the geometer, and the rigidity of the larva of the brimstone-moth, will be found to render the preparation of those specimens somewhat difficult. As we have already said, the skill necessary for such work can only be acquired by patience, perseverance, and the careful study of nature. The boy who has prepared and is admiring the caterpillar of the puss-moth, represented at the beginning of this Section, may very fairly be regarded as a master in this art.



Group of Caterpillars prepared from Nature.

1. Geometer Caterpillar of the common White Wave (*Cabera pursaria*); 2. Caterpillars of the Eyed Hawk-moth (*Sphinx ocellatus*); 3, of the Brimstone-moth (*Burnia cratægata*); 4, of the Puss-moth (*Cerura vinula*); 5, of the Leaf-roller (*Tortrix*); 6, of the Hawk-moth (*Sphinx*).



Section III.

The Beetle and Butterfly Collection.

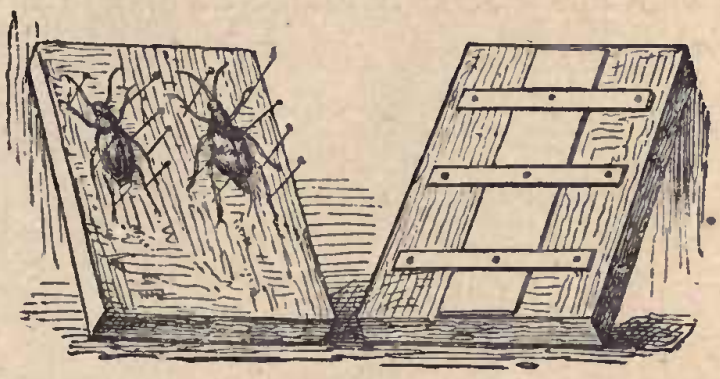
SETTING-OUT AND MOUNTING BEETLES AND BUTTERFLIES.

When it is intended to mount beetles, they should be taken out of the collecting bottle and placed on blotting-paper to dry. A pin should be thrust down vertically through the right wing-cover, so that its point will come out between the second and third pair of legs, without breaking the joint. The insect should be placed two-thirds up the pin, a uniform height being preserved through the collection, so that all in the cabinet stand on the same level. Very small beetles, which the finest pin would divide, should be gummed to the point of a triangular piece of card, and the pin thrust through the broad part. The legs and antennæ of larger insects must be spread out and properly arranged; for this purpose a slab of cork or turf will be found very useful. Sticking the pin in the slab so as to fix the insect, the organs of the mouth, where possible, the antennæ, and the feet should be set out with smaller pins in natural positions,

and then left to dry. If a cake of turf be used, pieces of wood may be nailed on behind to give it greater firmness and solidity.



Mounted Beetles.



Slabs for Mounting.

Some of the greater beetles, such as the common cockchafer (*Melolontha vulgaris*), may be spread out like butterflies in a flying position, not only their elytra or wing-covers being expanded, but their true membranous wings displayed.

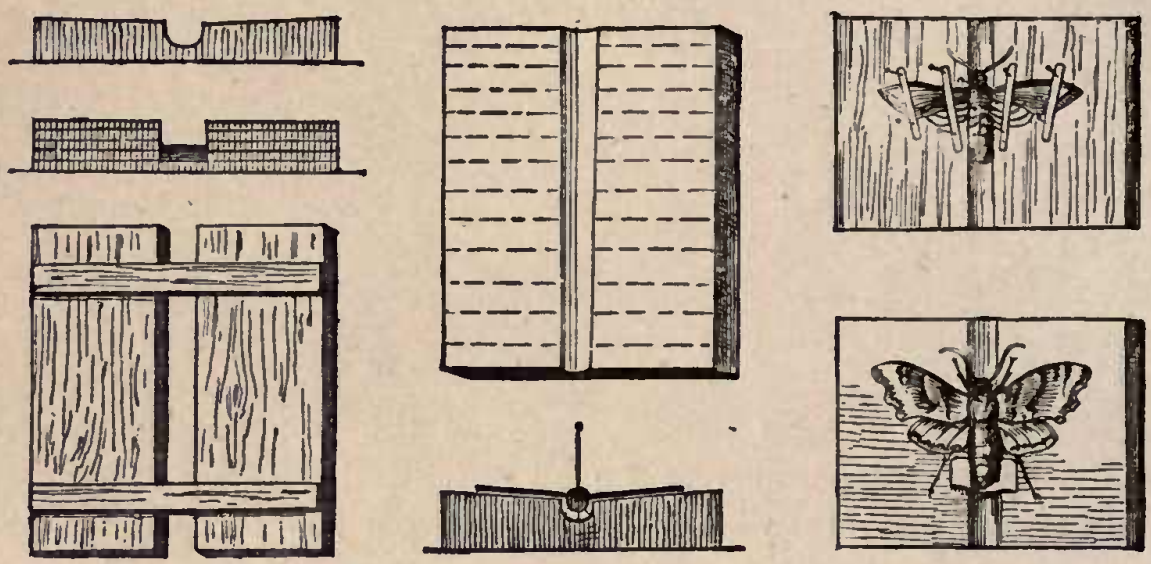


Cockchafer.

It sometimes becomes necessary to take away old pins and introduce new ones, or to spread out and display the limbs of insects after they have become stiffened and dried. Insects of all kinds may be relaxed, and their limbs rendered pliable and soft, by placing them in a moist sand bath overnight; in the morning it will be found that, by carefully turning the pins, they may be drawn out, and that the limbs, antennæ, and other parts can be re-adjusted.

In setting out insects it is desirable to have on one board insects approximating to each other in size, and collected, if possible, on the same day, so that all may be treated alike. The setting-board for butterflies consists of soft linden or poplar wood, containing a deep semi-cylindrical longitudinal groove, tapering on either side, so as to be the better adapted to the body of the insect. This board slopes a little towards the groove, in order to elevate the wings. When the wood is not soft enough, strips of cork may be glued to its surface,

the groove being furrowed in the cork; or two boards may be united with cross-pieces of wood, and the opening between them filled up with turf. It is desirable at first to draw lines across the setting-



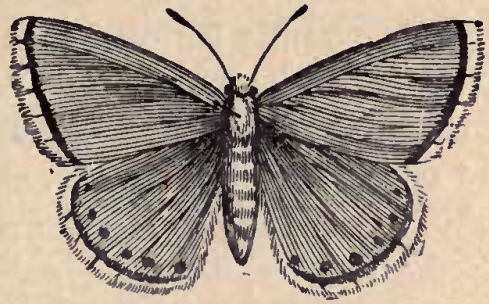
Setting-boards for Butterflies.

board at right angles with the groove, in order thereby to extend the wings at exactly the same height.

The body of the butterfly must be pinned down in the groove in such a position that the upper edges of the groove are at the same height as the centre line of the body of the insect, so that the wings may lie flat upon the board. With a needle the wings should be drawn apart until the inner margin of the border wings forms a right angle with the long line of the body; the hinder wings will thereby be exposed and drawn after the fore-wings so far that they will be partly covered by the posterior part of the fore-wings, their hinder portion only being visible. The wings thus stretched out must be fixed firmly and held in position by strips of cardboard laid across them, which should be pinned down to the setting-board. The antennæ and the first pair of legs must be directed forward at an acute angle, the other pair of legs directed backwards. The abdomen of the larger species should be supported beneath by layers of paper or cotton wool.

If the upper and under surfaces of the wings are very different in their appearance and markings, there should be duplicate specimens,

so that both surfaces may be displayed, as in the case of the beautiful argus (*Polyommatus Argus*): the upper side of the wings of which insect is blue, while the under side has many eyes, and a yellow border.



Argus, upper side.



Argus, under side.

The butterflies, after they have been displayed on the setting-out board, must be laid aside to dry in a place free from dust, airy and warm, but in the shade. The small ones dry quickly, but large species sometimes take three or four weeks, or even a longer time, before the process is completed. In order to determine whether they are dry, it is only necessary to touch the abdomen with a needle; if the skin is stiff and immovable, it may be concluded that all moisture has evaporated, and that the process of drying is completed.

PRESERVATION AND ARRANGEMENT OF THE COLLECTION.

We will now suppose that the season is over, and that after much toil in the hot sunshine and in all sorts of weather, and after many successful and happy explorations in field and forest, and much discouragement and failure, you have at last succeeded in getting together a fair sample collection of the insects of your neighbourhood. Naturally, you are anxious to preserve them from being injured or destroyed; and their proper scientific arrangement is equally desirable. You may have already expended some considerable time in unsuccessfully trying to find out the names of your insects; and perhaps you have laid out some money in the purchase of suitable collecting tools and materials for making insect preparations—pins and cork, store-boxes and setting-boards, for

moths and butterflies; and glass-stoppered bottles, containing spirits of wine, for beetles, etc.

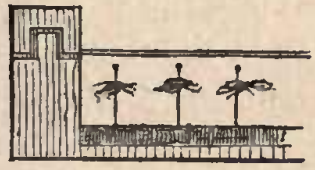
It frequently happens that a beetle and butterfly collection begun by boys in high spirits, and carried on for awhile with a corresponding amount of energy and success, is ultimately abandoned, because, as it has not been properly prepared, insects have attacked the collection. When this is the case, brown powder accumulates under the bodies of the insects; they are soon dismembered, and heads, limbs, and antennæ lie scattered through the cases. There has been no time to attend to the collection. The thoughts of the young collectors have been turned aside from natural history by the more urgent claims of study or business. They have noticed that some beetles are injured, while others have become mouldy, and that everywhere amongst them are signs of decay; and they have ceased to feel any interest in the collections of which they were formerly so proud. It is indeed a thousand pities when this happens. For the study of God's works must always furnish an inexhaustible supply of entertainment and instruction. It must never be forgotten that every beetle, butterfly, or other natural object is really the work of an Infinite and Eternal Being, whose "wonderful works" we can never fathom, however deeply we may examine them. Each star in the heavens, each flower or animal on the earth, is in reality the product of the hand of God. To study correctly these works of the Creator is the aim of natural history, and certainly there can be no grander or loftier employment. Not only, therefore, whilst young and strong, and capable of climbing the hills and mountains, in school-boy days, whilst free from the cares of business, but in after years, let us keep up our acquaintance with natural history. That our readers may have this pleasure, and may again work at their insects with renewed hope, we shall now give them some hints as to the best means of preserving their accumulated treasures, and also show how to arrange and name them scientifically in the cabinet.

The principal condition for the preservation of insects is the careful and skilful preparation of the specimens. As we have already intimated, the collection often contains the germs of its own destruction from the moment of its origin. The greatest cleanliness

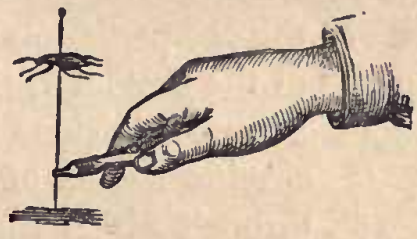
of setting-boards and store-boxes, their absolute freedom from worms, and the perfect dryness of insects, especially such as have been killed in water or spirits, should be made a constant aim. Newcomers from other collections, or suspected inhabitants, should be carefully examined for those small insects which do so much mischief.

Before any scientific arrangement is attempted, boys should make a catalogue of the insects in their collection, as far as their names have become known to them; they will thus obtain a better idea of what they have and what they require, and can thus intelligently supply their own deficiencies. Passing in review the number of genera and species already possessed, they must next proceed to arrange their collection according to some trustworthy text-book, as Stephens' *British Coleoptera*, Westwood's *British Butterflies*, Newman's *British Moths*. The number of extra insect-boxes required for the collection to make it complete can thus be determined.

The boxes should be made out of dry wood, perfectly sound, and free from worms; if there are any cracks or openings, they must be



Section of Insect Box.

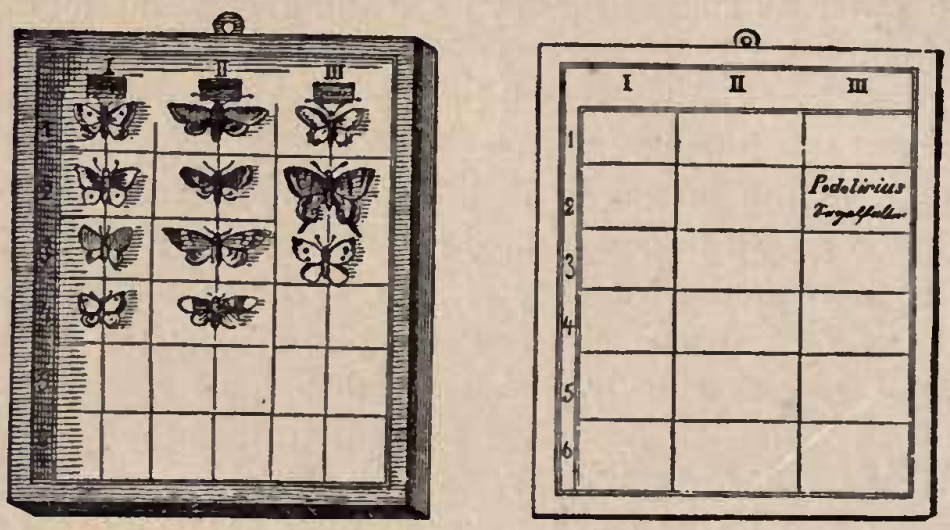


Insect Forceps.

closed with wax or putty. The cover should work on hinges, and open and shut so as to close accurately over the sides of the box. The joinings must be carefully adjusted, and may be further secured by a lining of cloth where the cover and the sides of the box meet. The bottom of the box should be covered with cork, and lined with white paper. Fine needles, with the insects attached to them, may be most conveniently pressed down into the wood or cork of the boxes with a pair of forceps.

Smaller collections may be arranged in drawers, to slide in or out on the shelves of a cabinet, which is opened or closed with folding-doors. The insects should be arranged in columns at the bottom

of each drawer, lines being drawn at equal distances vertically and horizontally, so as to mark out the whole space into distinct compart-



Collecting Drawers.

ments, one for each insect. The perpendicular columns should be marked with Roman and the horizontal lines with English figures, so that any compartment can be easily found by the two kinds of numbers. In the compartments thus mapped out, the scientific names are registered at the bottom of the drawer, as in the figure above.



Mounted Insect and Ticket.

For more minute divisions and subdivisions, the generic and specific names of the insect are written on a ticket, through which the pin is passed, so that the ticket is placed below the insect. The name of the family may be printed at the head of the column. Genera, when closely allied and only represented by one species, are placed next each other, as well as the specific forms of the same genus. Large public collections of insects should always be inspected as opportunity offers. There collectors will not only see and anticipate the riches of nature yet in store for them, but they will be able generally to find out the scientific names of insects in their own collection, and learn other things about it of which they can take note, and which will add to its educational value. To determine the names of beetles and butterflies, numerous text-books for beginners have been published, from which our readers can make their own selection.

The following is an outline sketch of the two great orders of beetles and butterflies, with the principal divisions and subdivisions of their families.

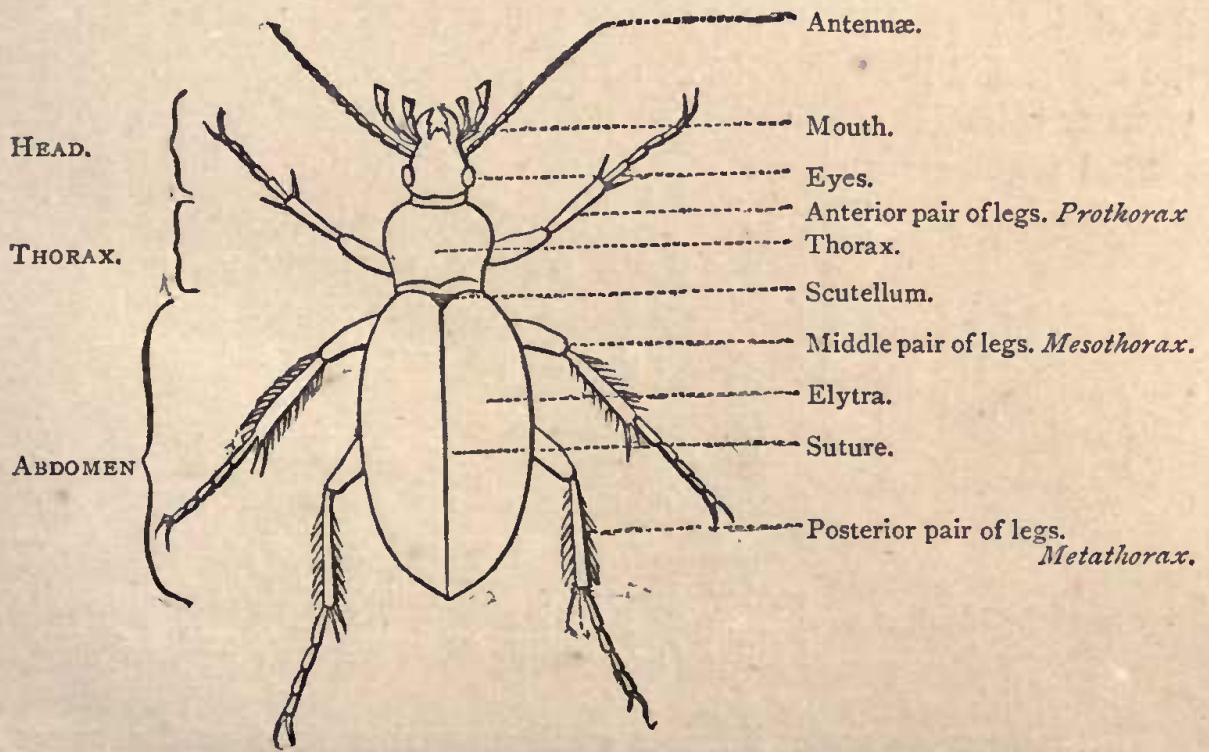
Order I.—Coleoptera, or Beetles.

The beetles form the first order of the class of *insects*. They are distinguished from the other orders by the masticating or biting parts of the mouth (mandibles), as also by their horny wing-covers (elytra) and membranous wings.

In every coleopterous insect there are three obvious divisions, —the head, the thorax, and the abdomen.

The Head.—The head appears as a single piece, without any obvious suture or division, and is generally of a harder substance than the rest of the body. The form is most commonly triangular, with the angles somewhat rounded. The hinder part is occasionally narrowed into a short neck, which works in the interior cavity of the thorax, and therefore admits of a considerable degree of motion in every direction.

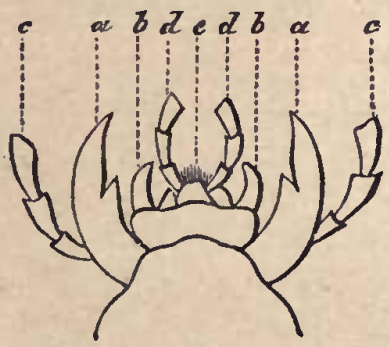
THE PARTS OF A BEETLE.



The head contains the mouth, two antennæ, and two compound eyes. The thorax consists of three segments, viz., 1, the prothorax, to which the first pair of legs and the neck are articulated; 2, the mesothorax, which contains the second pair of legs and the mesothoracic pair of wings, or the horny elytra, or wing covers; 3, the metathorax, to which are attached the third pair of legs and the metathoracic pair of membranous wings, which are protected or covered by the elytra.

The elytra vary greatly in form, and are sometimes very handsome, as in the red-spotted caterpillar-hunter (*Calosoma calidum*), an American beetle common in Pennsylvania. When expanded they are of little use in flight, generally remaining nearly motionless. When closed they meet along the back in a straight line, called the suture. Sometimes the elytra adhere along the suture permanently, so as to prevent the expansion of the wings, which are consequently never developed, as in the churchyard-beetle (*Blaps Mortisaga*) and the family *Melasoma*.

The portion of the body immediately behind the metathorax is called the abdomen, and consists of a series of rings or segments, usually nine in number, moveable upon each other, and divided into dorsal and ventral rings, the former being more or less covered by the elytra, and the latter visible on the under surface. The breathing pores or spiracles are situated on the upper inflected portion of the ventral segments, and are easily discovered on the removal of the elytra and wings. These spiracles, called trachæ (Gr., τραχύς, rough; hence Lat., *trachea*, an air-tube), are each furnished with a muscular apparatus, by means of which the insect can close the aperture at pleasure.



Parts of the Mouth of a Carabus.

In the masticating or biting insects the mouth consists of six separate organs: *a*, Mandibles, or upper jaws; *b*, Maxillæ, or under jaws; *c*, Maxillary palpi; *d*, Labial palpi; *e*, Labium, or lower lip, and Labrum, or upper lip.

The *labrum*, or upper lip, is a small moveable piece on the upper

side of the mouth, closing it from above. Its form is variable, commonly quadrate, wider than its length, and sometimes rounded or triangular.

The *mandibles*, or upper jaws, are two strong horny projections, which take their rise one from each side of the mouth, immediately beneath the upper lip, which usually covers their base. They are generally of a triangular form, more or less curved, especially toward the tip, and usually toothed or serrated on their inner edges. The term mandible, derived from Lat., *mando*, to chew, at once indicates their function, which is to bite and bruise the food.

The *maxillæ*, or under jaws, are inserted on each side of the mouth, immediately below the mandibles. As with the last-named organs, their action is horizontal, but their texture is less hard than that of the others, their colour paler, and their internal edges are ciliated, or fringed with hairs. These organs are simply accessories to the mandibles, and are employed sometimes in simply holding the food which the upper jaws are engaged in cutting to pieces, or in subjecting the food to a still finer division, after the harder parts have been bitten and broken by the more powerful action of the upper jaws.

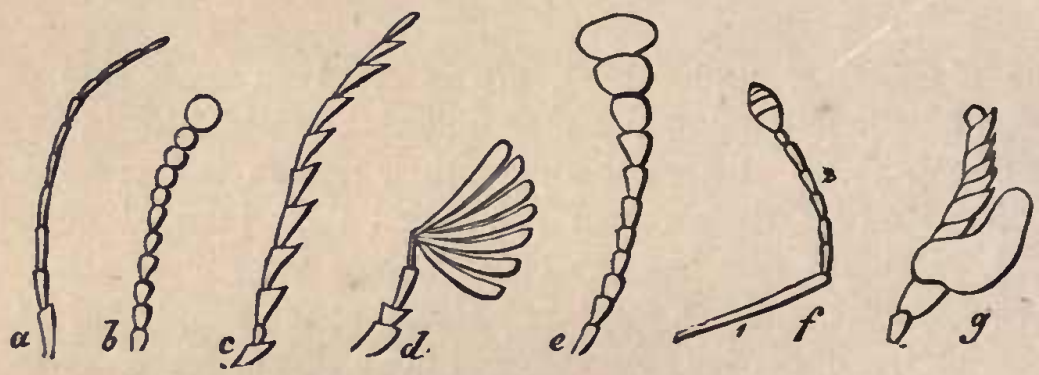
The *maxillary palpi.*—Towards the middle of the outer edge of the maxillæ there emerge two slender-jointed, filiform, thread-like processes, named palpi. These are called maxillary palpi, to distinguish them from the labial palpi, which take their origin in the labium, or under lip. These organs generally consist of four joints, of which the terminal one is remarkable for the variety of forms which it assumes, affording valuable characteristics for specific description. The palpi are susceptible of rapid vibration, and are supposed to constitute the organs of touch.

The *labium*, or under lip.—As the mouth is covered by the labrum, so it is closed by the labium. This part is situated between the maxillæ, and is composed, as it were, of two portions joined together by their inner edges. The part immediately behind, which may be considered as forming its base, is named the chin (*mentum*). This piece is usually transverse, or broader than its length, and is in

most instances sinuated or notched in the middle of its anterior edge, with an acute tooth in the centre of the notch, which is sometimes cleft in two parts.

The *labial palpi.*—These are similar to those borne by the maxillæ, only smaller, and are attached to the lateral margin of the labium, projecting from each side. They consist of three moveable articulations, attached to a fourth, which is adherent and forms a support to the others.

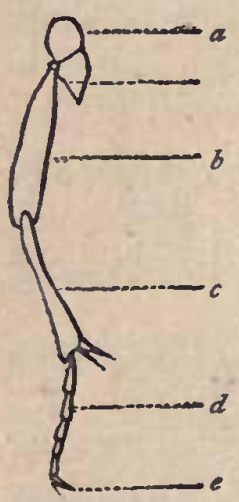
The *antennæ.*—These are the most conspicuous appendages of the head; they are two jointed organs which stand out like



Forms of Antennæ.

a, Bristle-form; *b*, necklace-form; *c*, serrated, having teeth like a saw; *d*, lamellate (Lat., *lamella*, a thin plate); *e*, clavate, or club-formed; *f*, geniculate, or bent so as to form a knee or angle; *g*, irregular.

horns from the forehead, and are inserted a little in front of the region of the eyes. The antennæ are usually composed of eleven conical tubular joints. The function of these organs is not known.



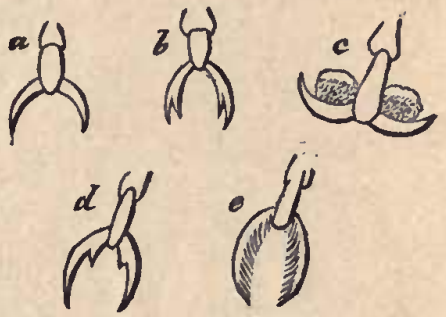
Leg of a Beetle.

Great difficulty has been experienced by entomologists in forming a simple natural classification of this most numerous order of insects, on account of the great number of species which it contains, and their general resemblance to each other. No better system of arrangement has yet been devised than that made by the French naturalist Latreille, who took as the foundation of his classification the number of joints in the tarsus or last portion of the foot.

In beetles there are six legs, each of which may be considered as composed of four principal pieces, viz., the coxa, or

haunch, *a*; the femur, or thigh, *b*; the tibia, or shank, *c*; and the tarsus, or foot, *d*; and the claws, *e*, as represented in the preceding figure.

The last joint of the tarsus supports the claws (*e*), which are: *a*, simple; *b*, cleft; *c*, lobed; *d*, toothed; and *e*, serrated.



Parts of the Claws.

Between thirty and forty thousand sorts of beetles are now known to naturalists, and it cannot be doubted that as many more remain to be discovered; and, although there are many exceptions, yet the vast majority of these insects may be satisfactorily arranged under the following four sections, which were first proposed by Latreille.

THE CLASSIFICATION.

Section 1.—PENTAMERA (Gr., *πέντε*, five; and *μέρος*, a division). Carnivorous beetles, some living on the land, others in the water, having five joints to the tarsi of all their legs. This section contains the greatest number of beetles, which have been divided into the following families:

1. CARNIVOROUS BEETLES (CARNIVORA). These are again subdivided into two classes, inhabiting respectively the land and the water.

(*a*) *Land Beetles.*—The tiger-beetles (*Cicindelidæ*), which are pre-eminently carnivorous and rapacious in their habits, and are easily detected by the rapidity of their motions, their large prominent eyes, and their metallic lustre. They run quickly, and take flying leaps, alighting on the back of other beetles, chiefly vegetable-feeders, which they instantly tear to pieces. They hunt in dry sandy situations, and are most active about noon, flying about in the hot sunshine. The larvæ excavate cylindrical burrows in the earth, and are as voracious as the perfect insect. These beetles are most abundant in the summer months.

The ground beetles (*Carabidæ*) have ordinarily the head smaller than the thorax, and are similar in their carnivorous habits to the preceding group. They also run quickly over the ground, are usually of a darker colour than the tiger-beetles, being often of a beautiful bronze hue. These beetles are found hiding under moss, stones, and the bark of trees, and, like the *Cicindelidæ*, are very useful to the farmer and gardener in the extirpation of other insects, especially such as feed on vegetables. The *Carabidæ* are somewhat nocturnal in their habits, and are to be found at all seasons.



Ground Beetle.

(*b*) *Water Beetles* (*Dytiscidæ*).—The aquatic division of this section of carnivorous beetles consists of Coleoptera, both large and small, which habitually reside in the water. Hence their bodies are oval or boat-shaped, their antennæ are formed like bristles, and their legs are flattened, compressed, ciliated on the margin, and fitted to serve as oars. All these beetles are air-breathers; and as there is not enough for them in the water, they are obliged occasionally to seek the surface for a renewed supply from the atmosphere. This is done by resting on the surface, and raising their elytra or wing-covers. The air is thus brought into contact with their spiracles, or breathing-pores. The larvæ reside in the water, and are as voracious as the imago, or perfect insect, feeding upon other aquatic insects, larvæ, and the ova of small fish. When about to change into the pupa state, the larva burrows into the bank of its native pond, and there undergoes its transformations. The diving water-beetle (*Dytiscus marginalis*), the large water-beetle (*Hydrophilus piceus*), the two-spotted agabus (*Agabus bimaculatus*), the furrowed acilius (*Acilius sulcatus*), the *Colymbetes fuscus*, and the common whirligig-beetle (*Gyrinus Natator*), are among the commonest genera of water beetles, and are most frequently found in ponds and fresh-water reservoirs.



Diving Water Beetle.



Whirligig Beetle.

2. BRACHELYTRA (Gr., *βραχύs*, short; and *ἔλυτρον*, a sheath), or beetles distinguished by short wing-cases and an elongated form of body, run and fly with equal agility. They have filiform or thread-like antennæ, a mandibulate, or chewing mouth, and feed chiefly upon dead and decaying animal and vegetable matter, fungi, rotten wood, and manure heaps. Some small and beautiful species are found in flowers. The larvæ are very similar to the insect in appearance, and are nourished by the same kind of food. To every insect has been assigned by the Creator some means of defence against its enemies. These beetles, when irritated or alarmed, have the power of secreting a very pungent and unpleasant odour, and on the least appearance of danger immediately assume a very threatening attitude, elevating their tails like a scorpion, and making believe to bite with their long and powerful jaws. This attitude, when assumed by some of the larger species, gives them a truly formidable appearance; as, for example, by a common black English species known as the "devil's coach-horse" (*Goerius olens*); yet this insect is quite harmless.

3. SERRICORNIA (Lat., *serra*, a saw; and *cornu*, a horn), or beetles distinguished by the serrated or toothed form of their antennæ. In this family the wing-cases, or elytra, completely cover the body, which varies greatly in appearance. Many interesting Serricornia inhabiting warm climates are remarkable for the splendour of their colours. The larvæ are chiefly vegetable-feeders, residing in the interior of plants. The following are the names of some of the most remarkable genera:

The spring-beetles (*Elateridæ*) are commonly found under the bark of trees, and are easily known by their power of rapidly regaining their feet by a spring upwards when laid on their backs, which very often happens, as their legs are very short. These beetles have, as it were, been made natural gymnasts, to remedy this defect in the structure of their limbs, affording an illustration of the all-pervading Divine law of adaptation of means to ends. A species of Elater inhabiting the West Indies is one of the most brilliant of fire-flies. The larvæ of some of the British species

live in the ground, and feed upon the roots of plants. The larva of one species devours the roots of corn, and is but too well known to the English farmer as the wire-worm.

The glow-worms (*Lampyridæ*), of which sufficient mention has been already made (see p. 10), are closely allied to the *Elateridæ*.

Very few of the *Buprestidæ* are found in Europe, and they but poorly represent the genus, which consists of large and splendidly-beautiful insects in tropical countries; some of those in India are upwards of two inches in length. Our native species are not above a quarter of an inch long; if an attempt is made to seize them, they counterfeit death, and fall to the ground, where it is next to impossible to find them: this is a common trick amongst insects to avoid capture! But patience in this, as in many other matters, will be rewarded; quietly wait and watch, and when all danger appears to be past, the creature will be discovered by its movements, and can then be retaken. Some of the *Buprestidæ* live for many years in the larval state. A merchant in the city of London had a desk that had been brought from India, in which was one of the grubs of a species of *Buprestis*. Several years afterwards the perfect insect made its appearance, and thereby put an end to many surmises of the merchant and his clerks as to certain scratchings which they had long heard in silent wonder.



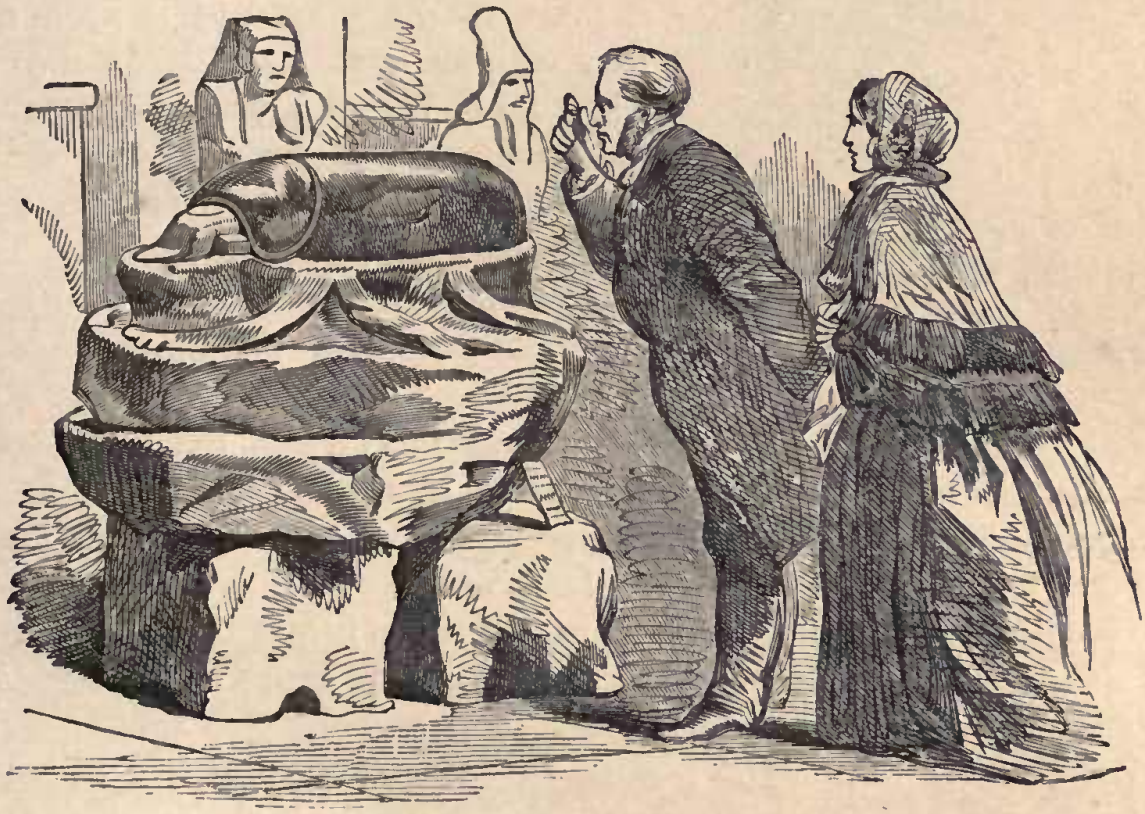
Death-watch Beetle.

The death-watch (*Anobium tessellatum*), already described, also belongs to the family of Serricorne beetles.

4. LAMELLICORNIA (Lat., *lamella*, a thin plate of metal; and *cornu*, a horn) have antennæ which terminate in a club or large knob, composed of several lamellæ or thin plates, disposed like the leaves of a book, or arranged like a comb or fan, which the insect can open or shut at pleasure. The insects of this family feed on manure and decomposing vegetable substances, on rotten wood, and the roots of plants. Their head and thorax exhibit a great variety of forms, and their limbs show many striking modifications of structure with especial reference to their instincts; in this respect it is one of the most beautiful families of the Coleoptera. The majority of the

beetles are of an uniform black or brown colour; some, however, display metallic colours of great brilliancy. The Lamellicorne family is subdivided into two leading groups, the *Scarabæidæ* and the *Lucanidæ*, of which the following are the most prominent and characteristic genera:

The sacred-beetle (*Scarabæus sacer*), the type of the first group, of which so many models and carvings have been discovered, occasionally of gigantic size, among the monuments and sarcophagi of the ancient Egyptians. The common dorr, or shard-borne beetle, as the boys



Sculpture of Sacred Beetle.

call it (*Geotrupes stercorarius*), which flies abroad in the evening, is appointed by the Almighty to be one of the most effective scavengers of the earth. And here it is worthy of remark that these beetles, notwithstanding their dirty employment, are themselves remarkable for the cleanliness and glossiness of their covering, and their habitual freedom from defilements of any kind. But "cleanliness is next to godliness," and purity of covering amongst animals seems to be a

precept throughout nature. Hence beasts and birds are almost incessantly cleaning and polishing, the former their fur and the latter their feathers. The cat licks and trims her coat; the canary washes and arranges his plumes; the beetle comes clean and untainted from its dirty home and feasts, and may be taken up without defiling the hands. These creatures thus read a lesson of cleanliness to those boys who have little liking for soap and water.

The common cockchafer (*Melolontha vulgaris*) devours the foliage of the oak and other trees as soon as it takes to the wing, and is itself the prey of innumerable birds. In seasons when these insects are abundant, they greatly injure the produce both of the field and garden in their larval state by devouring the roots of the crops. But in April the plough turns up their long white grubs, which the birds greedily pick up; and towards the end of May and June, when as beetles they attack the foliage, the birds again abate the nuisance; for nearly every sparrow has a chafer in its mouth, captured on the wing or snatched from the spray; the thrush and blackbird, and other insectivorous birds, also feast on them; and then our groves and woodlands re-echo their songs of thankfulness to their Creator.



Common Cockchafer.



Rose-Chafer.

The rose-chafer (*Cetonia aurata*) is a common British insect, about an inch in length, of an oblong oval form, green above, coppery red beneath, with white marks on the elytra. It flies well, with a humming noise, in the hottest part of the day, and feeds on the honey and pollen of flowers, not confining itself to rose-trees, although it seems to prefer them. In the larval state it is found in rotten wood and timber.

The other division of the Lamellicorne beetles comprises the

stag-beetles (*Lucanidæ*), of which the stag's-horn-beetle (*Lucanus Cervus*) is a characteristic species. It flies about the oak on summer evenings, upon the wood of which the larva feeds. This and the small stag's-horn-beetle (*Dorcus parallelipipedus*) are both British beetles.



Stag Beetle.

(5) CLAVICORNIA (Lat., *clava*, a club; and *cornu*, a horn) is a class of beetle having antennæ which become enlarged and club-shaped at their extremity. This family includes the group of carrion beetles (*Necrophori*) already described; and the skin-beetles (*Dermestidæ*), of which the larvæ are very voracious, feeding on the skins or carcases of animals, and often committing great ravages in fur warehouses; the bacon-beetle (*Dermestes lardarius*), and the fur-beetle (*Attagenus Pellio*).

Section 2.—HETEROMERA (Gr., ἕτερος, different; and μέρος, a division) are phytophagous, or plant-eating beetles, having five joints to the tarsi of the first and second pair of legs, and only four joints to the hinder tarsi. The beetles of this section have been arranged under the following families:

1. The *Melasoma*, or black-bodied beetle, to which the churchyard-beetle (*Blaps Mortisaga*) belongs—a common British insect of a black colour, found in damp, dark, and dirty places about houses; also the *Tenebrionidæ* (Lat., *tenebræ*, darkness), so called because these insects avoid the light, and are most active at night. The meal-worm beetle (*Tenebrio Molitor*) belongs to this family, of which the larva, known as the meal-worm, lives on flour, meal, and bran, and, like the perfect insect, does much damage in corn-mills, granaries, and bake-houses.

2. The *Trachelia*, or neck-beetle, in which the head is united

to the thorax by a distinct neck, is active in the day-time, devouring the leaves and feeding on the juices of flowers; the colours of some of this species, as the blister-beetle (*Cantharis vesicatoria*) being sometimes brilliant. This beetle is of a shining green metallic lustre, and is imported from Italy and Spain as a means of raising blisters on the skin. For this purpose the insect is reduced to powder, which, mixed with ointment or lard, is spread on linen or leather, and then applied to the skin. Closely allied to this insect is the oil-beetle (*Meloe Proscarabæus*), which appears in spring, and is frequently seen on the leaves of the common catchweed (*Galium aparine*), over the foliage of which it crawls slowly. When alarmed, it sends out from the joints of its legs an oily, yellowish liquor, which constitutes a means of defence.



Oil Beetle.

Section 3.—TETRAMERA (Gr., τέτταρες, four; and μέρος, a division) are plant-eating beetles, having four distinct joints to all the tarsi. The larvæ of these insects generally live in the interior of vegetables and trees, often doing great injury to timber. They appear to pass a considerable time as pupæ thus concealed, as the perfect insects have been known to eat their way out of wood even after it had been for some considerable time worked up into furniture.

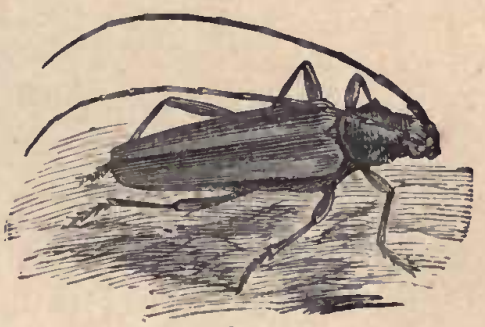
The following families contain the insects under this section. A few of the most interesting of the genera only are mentioned.

1. *Phytophaga* (Gr., φύτον, a plant; and φάγω, to eat) are small insects feeding on plants, both as larvæ and beetles, many of them doing great damage to crops, as the turnip-fly (*Haltica Nemorum*), a little jumping beetle, having the posterior thigh thickened. The tortoise beetle (*Cassididæ*)—of which the common green cassida (*Cassida viridis*) is a typical form, often seen during summer on the leaves of the mint,—is a singular insect, resembling the animal after which it is called. The body is round, slightly convex and marginal, with

a horizontal expansion of the thorax and elytra, under which the head and limbs can be completely withdrawn and concealed. The larvæ are furnished with forked tails, which project over their backs, and thus forms a portable shelter.

The sub-family of golden beetles (*Chrysomelidæ*) are of an egg-shaped form, and ornamented with beautiful colours, among which blue, gold, and green are conspicuous. The most common species in England are the *Chrysomela populi* and *betulæ;* the former is found upon the leaves of the poplar, the latter on those of the birch.

2. *Longicornes*, or longicorn-beetles, are distinguished by the great length of their antennæ, which are always as long as the body of the insect, and often much longer. Some of the foreign species are brilliantly coloured, and others exhale an agreeable musky odour, as the musk-beetle (*Cerambyx moschata*), one of the handsomest of British beetles, possessing a fine green metallic hue, shaded with blue and gold. It is very common on willows.



Musk Beetle.

3. The *Rhyncophora*, or weevil family (Gr., ῥύγχος, a snout; and φέρω, to bear), have the head prolonged into a snout, at the end of which the mouth is situated, the antennæ being short, elbowed, and inserted at the sides of the snout in every intermediate position from base to apex. To this family belong:

The nut-weevil (*Balaninus nucum*), whose larva is the little white grub so frequently met with in nuts and filberts; the pea-weevil (*Bruchus pisi*), the larvæ of which makes the small circular holes observed in peas, sometimes even destroying the entire pea crop; the corn-weevil (*Calandra granaria*), which often commits great havoc in granaries. These insects are effectually destroyed by kiln-drying the wheat.

Most of the *Rhyncophora* are more or less covered with minute scales, like those on the wings of butterflies, and there are species of great beauty which, under the microscope, exhibit in their scales a splendour of colour equal to that of our most beautiful native butterflies; they are found on every common bank of nettles in England.

In some foreign species, as the diamond beetle (*Curculio imperialis*) these scales are truly magnificent.

4. *Xylophaga*, or wood-eaters (Gr., ξύλον, wood; and φάγω, to eat), usually live in wood and bark, especially that of the pine and fir, which they perforate and channel in all directions, interrupting the flow of the sap, and loosening the bark from the wood, so that the tree is ultimately killed. The typographer-beetle (*Bostrichus typographus*) is so named from the figure of its burrows. These are often very pretty, although the insect producing them is most destructive to the pines, especially in the Hartz Forest of Germany; where, in 1783, one million and a half of these trees are said to have been destroyed. The saw-beetle and the *Cerambyx heros* are Longicorn beetles.



Saw Beetle.



Cerambyx heros.

Section 4.—TRIMERA (Gr., τρεῖς, three; and μέρος, a division) include those beetles which have three joints in each tarsus. To this section belongs the family of the lady-birds (*Coccinellidæ*), of which the *Coccinella septempunctata*, or seven-spotted lady-bird, a well-known summer visitant of every field and garden, is a typical form. These insects are of great service to plants, by greedily devouring the aphides, or plant-lice, which infest them, and this they do both in the larval and the perfect state.

In reviewing the various phenomena of insect life manifested by the order Coleoptera, we are naturally led to consider that remarkable substitute for reason in the lower animals which is called instinct. Now, however we may regard instinct—whether as a manifestation of reason, the same in kind as our own, but inferior only in degree; or as different in kind, and having nothing in common with human intelligence—we are assured of one truth: that insects, as well as ourselves, have been carefully supplied with an abundance of such food as they require, together with capacity for choosing suitable food, also with some means of protection against their natural enemies, and of defending themselves when they observe danger approaching. It is matter of little moment by what name we call these capacities; but it is of consequence that we recognise in them the wise arrangement and the merciful care of God. We see, too, that in merely following the bent of their own inclinations or natural instincts, these creatures are, in some way or other, usefully employed, and working for God, in whom all created things "live, and move, and have their being." God has given them their instincts, and still directs them; so that insects are really only instruments under the control of Him who has allotted to each its station and duties in life,—fulfilling the purpose of Him who is "wonderful in counsel and excellent in working."

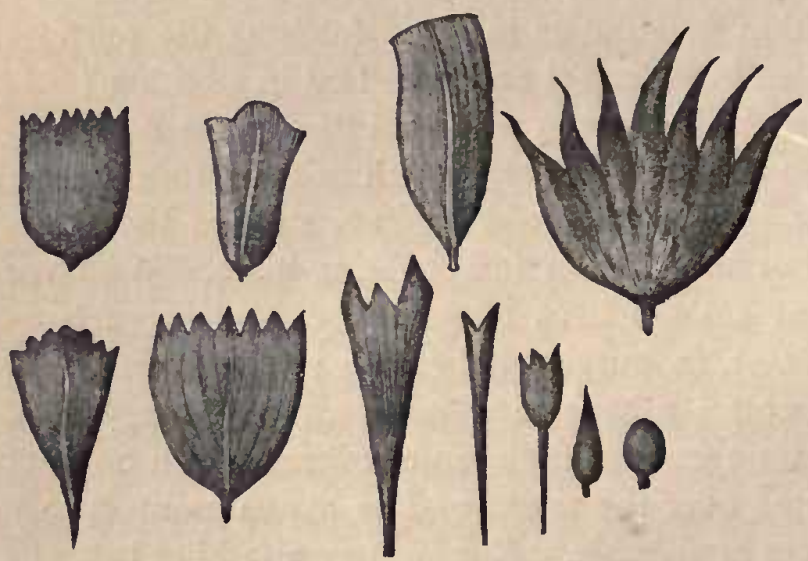
It has been also shown that weeds and wild flowers, in countless millions, minister to the wants of beetles, which in their turn furnish food not only for their own carnivorous families, such as the *Cicindelidæ* and *Carabidæ*, but for hosts of insect-eating birds. We have seen how usefully spent are the lives of scavenger beetles, such as *Geotrupes* and *Necrophorus*, in burying below the soil nuisances left on its surface, which would otherwise contaminate the air, whilst providing at the same time food for their future offspring. In nothing is the care of the Creator over the works of His hands more clearly seen than in the instincts of animals. Nor is there anything beneath the dignity of the Creator in this constant oversight and guidance of the humblest of His works, any more than there is in His care of man. We read in the Scriptures that we ourselves are comparatively insignificant, and that our earth itself, with all the nations that tread its surface, is "as a drop of a bucket" in His presence. How truly

sublime is the Scripture conception of the Supreme Being, so beautifully confirmed as it is by the discoveries of science and the teachings of the microscope and telescope as to the extent, magnificence, and duration of the universe!

All of us should aim at acquiring grand and ennobling conceptions of the grandeur and extent of God's universe. To do this we must "search the Scriptures," and study God's works in nature, which, when properly understood, are ever in harmony in their teaching, and are only different revelations of Himself; but how far inferior in brightness to that "light of the glorious gospel of Christ, who is the image of God!"

Order VII.—Lepidoptera, or Butterflies and Moths.

The order of Lepidoptera (Gr., λεπίς, a scale, and πτέρον, a wing) is characterised by the downy covering of their wings, which are four in number. The down, when rubbed off, appears like powder or farinaceous dust, but under the microscope it is seen to consist of layers of beautiful scales, arranged in rows on the membranous framework of the wings, and overlapping each other like tiles on the roof of a house. The number of these scales is very great; according to Leuwenhoeck, there are more than 400,000 on the wings of the silkworm-moth. In some species the wings are partially or even almost wholly devoid of scales; and, in others, small patches of the wings only are thus denuded, as in the great atlas moth (*Saturnia Atlas*). The bodies of the Lepidoptera are always more or less covered with hair; their antennæ are of variable form, feathery, bristle-form, or clubbed; and, as they feed on the honey or juices



Scales of Butterflies.

of flowers, their mouth is provided with a slender tubular apparatus, which they carry coiled up like the mainspring of a watch, and which in a moment is darted down to the bottom of the corolla, or flower-cup, whence the honey or food of the insect is sucked up through the centre of the tube.

CLASSIFICATION OF BUTTERFLIES.

The Lepidoptera are subdivided into two great groups, or sub-orders, named after the form of their antennæ, *Rhopalocera*, or club-horned (Gr., ῥόπαλον, a club; and κέρας, a horn), and *Heterocera*, or variable-horned (Gr., ἕτερος, various; and κέρας, a horn). The first group includes all the butterflies whose antennæ are invariably clavate, or club-shaped; and the last all the moths, which have antennæ of various forms, usually bristle-shaped, or like a plume of feathers, but very rarely club-shaped.

The number of butterflies and moths already known to naturalists, according to Dr. Burmeister, amounts to not fewer than twelve thousand species, and of these nearly two thousand have been described as British. These species of Lepidoptera are included in the above two groups or sub-orders, and have been further classed into diurnal and nocturnal Lepidoptera, according to their time of flight.

The Diurnal Lepidoptera, or Butterflies (*Diurna*).

The Diurnal Lepidoptera include all those species commonly known as butterflies, which fly only by day, having antennæ clavate or clubbed at their extremities, and whose wings are vertical, or stand upright in repose. Their caterpillars have usually sixteen feet, which are attached in pairs to the body, and nine spiracles, or breathing orifices, on either side. The first three pairs of caterpillar feet enclose those parts which are developed into the legs of the future butterfly; the remaining five pairs are membranous, thick, and short, and are finally lost with the moulting of the skin.

The pupæ of British butterflies are nearly always naked, or destitute of any silken envelope or cocoon; there are a few, however, which are so provided, and which conceal or hide their cocoon,

although their number is small, and they are insignificant in appearance; but in tropical and sub-tropical climates they are very large, abundant, and showy.

The following is a classification of British butterflies, with their orders, families, and genera, according to Edward Newman, F.L.S.

Section I. Butterflies known as Exposers (*Detegentes*), whose pupæ are naked or exposed.

This section includes the greater part of those butterflies which are natives of the United Kingdom. They are exposed in the chrysalis state to the full influence of the weather,—heat in summer, and cold in winter, with wind, rain, and snow; so that their pupæ are frequently found frozen in winter into solid and brittle lumps of ice, which may even be broken in pieces without exhibiting the slightest symptom of vitality; yet if left undisturbed they will recover, and revert to the condition in which they were when the frost overtook them. This section is subdivided into two subsections.



Silver-washed Fritillary.

A. Butterflies having only four perfect legs instead of six, and the pupæ suspended by the tail (*Suspensi*). This subsection is divided into—

Natural Order 1. Spine-bearing caterpillars (*Spinigeri*), which embraces four families—

1. Silver-spotted fritillaries, *Argynnidæ* (Gr., ἄργυρος, silver). Silver-washed fritillary, *Argynnis paphia.*



Scabious Butterfly.

2. Gregarious fritillaries (*Melitæidæ*). Example, greasy fritillary (*Melitæa Artemis*), or scabious butterfly.

3. Angle-wings (*Vanessidæ*). Comma butterfly (*Vanessa C-album*). The name of this species refers to a white mark

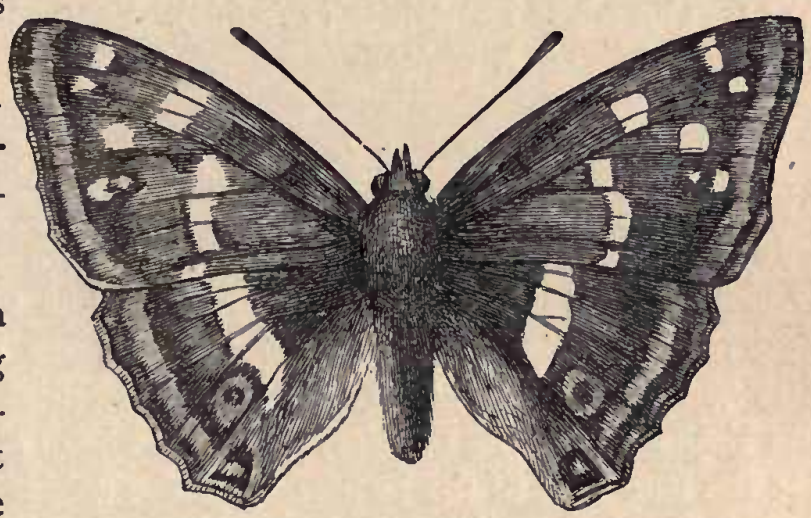
on the dark brown under surface of the hinder pair of wings, resembling, some say, a comma, and others, the letter c.

4. White admirals (*Limenitis*). Example, white-admiral butterfly (*Limenitis Camilla*).

Natural Order II. Slug-shaped caterpillars (*Limaciformes*).

5. Emperors (*Apaturidæ*). Example, purple emperor (*Apatura Iris*). This is the most beautiful of all the British butterflies, having a bold and soaring flight. The chrysalis is of a pale green hue. The caterpillar feeds on the leaves of the oak, ash, and willow. The perfect insect appears in July.

6. Satyrs (*Satyridæ*). Example, ringlet butterfly (*Hipparchia Hyperanthus*).



Emperor Butterfly.

B. Butterflies with six perfect legs, having girted chrysalids (*Succincti*), or pupæ not only suspended by the tail, but also supported by a belt of silk, which passes round the middle of the pupæ, and is firmly fixed on either side. This second sub-section is divided into—

Natural Order III. Woodlouse-shaped caterpillars (*Onisciformes*), in which the caterpillars are shaped like a woodlouse.

7. Dryade (*Erycinidæ*). Example, Duke of Burgundy butterfly (*Nemeobius Lucina*).

8. Argus butterfly (*Lycænidæ*). This family includes several distinct groups of small but beautiful butterflies, as the hair-streaks (*Theclæ*), coppers (*Lycænæ*), and the blues (*Polyommati*). The majority of these butterflies have the under surface of the wings ornamented with eye-like spots of various colours The caterpillars resemble woodlice, and the chrysalis is short, blunted at each end, and girt round the middle, as well as attached by the tail.

Natural Order IV. Cylindrical or worm-shaped caterpillars (*Cylindracei*, or *Vermiformes*).

9. Redhorns (*Rhodoceridæ*), so named from the colour of their antennæ. Example, clouded yellow butterfly (*Colias hyale*).

10. Swallow-tails (*Papilionidæ*). Many of the butterflies of this family have their hind-wings extended into a pair of tails, whence they have obtained the name of swallow-tails. The family of Papilionidæ is abundantly represented in the tropics; but only one species is found in England—the swallow-tailed butterfly (*Papilio machaon*).

11. The white butterflies (*Pieridæ*). Example, large white cabbage butterfly (*Pieris brassicæ*).

Section II. Concealers (*Celantes*). Butterflies whose caterpillars hide themselves in a silken follicle or cocoon before changing into chrysalids. These cocoons are usually hidden in rolled leaves, in clefts of the bark of trees, and at the roots of grasses. The Concealers may be regarded as an intermediate form between butterflies and moths, and as a type of the butterflies of warmer climates the Exposers, on the contrary, or those whose chrysalids are exposed, are the true type of the butterflies of the colder climates of the north. The Concealers undergo their transformation into chrysalids after the manner of moths, and may be all included in one family—that of the

12. Skippers (*Hesperidæ*). Butterflies with six perfect legs; wings, when at rest, in a semi-vertical position, never upright, and lying back to back. The members of this species are of comparatively small size and dim colour, and have a peculiar short, jerking mode of flying, which has obtained for them the name of skippers. Example, grizzled skipper (*Hesperia malvæ*).

Nocturnal Lepidoptera, or Moths (*Nocturna*).

Moths are easily distinguished from butterflies by their time of flight, which is usually in the morning or evening twilight, or during the night; by their antennæ, which taper to a point instead of termi-

nating in a knob; and by the position of their wings, which are not upright, but horizontally extended or turned downwards when the moth is at rest. The division between the thorax and abdomen of a butterfly, too, is more distinct than in a moth, where there is no such well-marked separation of these parts. Hence butterflies are called in science *Lepidoptera pedunculata*, or Pedunculated Lepidoptera; and moths *Lepidoptera sessiliventrea*, or Sessile-bodied Lepidoptera.

The Nocturnal Lepidoptera are now divided by our best entomologists into sections and families, as follows:

Section I. NOCTURNI, or the Sphingides and Bombycides of Linnæus. Thirteen families are comprised in this section, but we can only mention the most remarkable.

1. Hawk-moths (*Sphingidæ*). These are robust and powerful insects, easily distinguished by their large size and peculiar flight, only seen on the wing in the twilight hour, when they hover like hawks over the flowers, from which they extract the honey with their long tubular



Hawk-Moth.

proboscis. The caterpillars are naked, cylindrical, sixteen-footed, with a curved horn at the extremity of the body, and are remarkable for the peculiar attitude which they usually assume, resembling that of the sphinx of ancient Egypt, from which the name of the family is derived. Example, hawk-moth (*Sphinx Ligustri*). The most

remarkable member of this family is the death's-head moth (*Acherontia atropos*), distinguished by the skull-like patch on the back of the thorax, as well as by the squeaking sound which the insect emits when disturbed or irritated.



Clear-Wing Moth.

2. Clearwings (*Sesidæ*). Moths flying in the hottest sunshine, with a hovering motion, distinguished by the transparency of a portion of their wings. These moths are certainly an exception to the law of the twilight or nocturnal hour, when moths are usually awake and active. Example, bee-formed clear-wings (*Sesia bombyliformis*, *Sesia fuciformis*).

3. Swifts (*Hepialidæ*). This family contains two interesting genera, *Hepialus* and *Cossus*. The moths of the genus *Hepialus* are called swifts from the rapidity of their flight; the males and females are very dissimilar in colour. Example, ghost-moth (*Hepialus humulus*); probably so called because, in the twilight, it may be seen with tolerable distinctness, if it flies below the level of the eye, on account of its silvery-white colour above; whereas if it rises above the level, the brown colour of the underside of the wings renders it almost indistinguishable; it appears, therefore, to pass suddenly out of sight. The genus *Cossus* contains the goat-moth, so called from the scent emitted by its larva. The goat-moth is one of the largest of the British Lepidoptera, and remains three years in the larval state, during which time it is engaged in destructive operations,—perforating the timber of trees, and killing them by inches; this destructiveness is alluded too in its specific name, *Ligniperda*, or wood-destroyer.

4. Silkworm-moth family (*Bombycidæ*). The moths of this family are large, with plumose or feathered, thick, stout, hairy bodies, white, grey, or fawn-coloured wings, and six stout legs. All assume the pupa state in a silken cocoon spun for its protection. Its most valuable member is the silkworm-moth (*Bombyx mori*), which lays its eggs on the leaves of the white mulberry tree (*Morus alba*), on which the larva feeds.

Section II. GEOMETRIDÆ, or Geometers. This section is of some considerable extent, embracing seventeen families. It takes its name from the peculiar mode of progression of its caterpillars, which are called loopers, or geometricians. These have six pairs of true legs at the front part of the body, and two pairs of claspers at the hinder extremity, without any intermediate feet, and therefore in progression proceed as follows: holding on by their hinder claspers, they extend their body to its greatest length, then putting down their forefeet, and taking firmly hold of whatever is before them, they unfasten their claspers, and draw them as near as possible to their forefeet. The intervening portion of the body between their forefeet and claspers thus becomes elevated into a sort of loop or arch. Again holding on by their posterior claspers, and unfastening their forefeet, they stretch out their body into a right line as before; when again, by the help of the powerful muscular grasp of their forefeet, they proceed onwards, measuring the ground over which they travel, every step of which they appear carefully to survey.



Surveyor Caterpillar.

Many of these caterpillars closely resemble in colour the bark of the plants on which they feed, and instinctively take advantage of this circumstance to deceive their enemies, fixing themselves by their claspers to a twig in a manner so stiff and motionless that they may be easily mistaken for a portion of the plant; by this means they escape not only the sharp eyes of the young naturalist, but even the more penetrating vision of insectivorous birds, who are continually on the look-out for such morsels. For the names of the families, genera, and species of this section of British moths the works of Mr. Newman and Mr. Humphreys may be consulted.

We give but one instance of a geometer, the common magpie-moth (*Abraxas grossulariata*), the caterpillar of which often deprives the gooseberry-bush of its leaves.

Section III.—The CUSPIDATES embrace four families, of which the most remarkable is the Ceruridæ, to which the puss-moth (*Cerura vinula*) belongs.

Section IV.—The NOCTUAS or NOCTUIDÆ. While most of the moths of this section, as the name implies, fly only by night, and appear in very sombre colours, hiding away during the day in crevices of bark and old walls, some species are in the habit of flying abroad in the day-time: the wings of these, especially the posterior or under wings, are more gaudy, as those of the scarlet under-wing (*Catocala*), and the gamma-moth (*Plusia Gamma*). The latter is so called in allusion to a silvery or gold-coloured shining mark, situated near the inner border of the upper wings, which resembles the Greek letter *gamma* (γ). The section is very extensive, and includes thirty-five families. The larvæ have from twelve to sixteen feet, and at the close of their caterpillar life let themselves down by a single thread to the earth, beneath the surface of which they undergo their transformation in cocoons.



Scarlet Under-Wing Moth.



Gamma Moth.

Section V.—The PYRALIDES. This section is of moderate extent, and consists of ten families. The moths are small, and their wings during repose are generally placed in a triangular form; example, the pebble moth (*Pyralis forficula*). The caterpillars of this species do much mischief to the leaves of the garden cabbage, and common horse-radish: it is for this destructiveness that the species is noted.

Section VI.—The TORTRICES, or LEAF-ROLLERS. This section comprises an extensive group of minute, dull-coloured moths, distinguished by their short filiform antennæ, and their broad triangular wings, which also assume the figure of a triangle when the moth is at rest. The

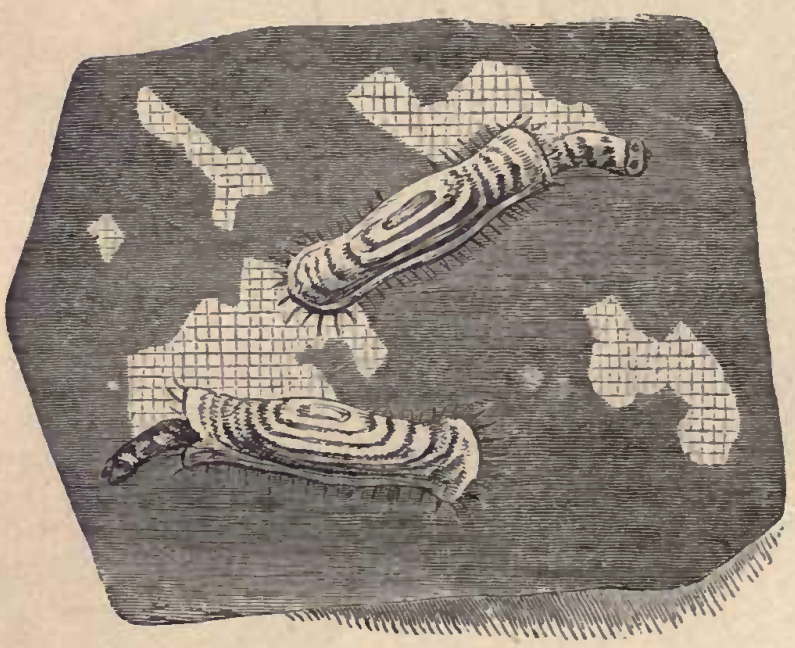


Leaf-Rollers.

larvæ are naked fleshy grubs, which live in the midst of their food, in a leaf curled up by the insect itself into a sort of tube, and securely fastened with silken threads. Within this they hide, mining their way into the leaf, and here they undergo their transformations. From this habit of larval existence they have derived their name *Tortrices*, or leaf-rollers. Although so minute and apparently insignificant, some of the species are very injurious. The larvæ of the

codling-moth (*Carpocapsa pomonella*) do great damage to the apple crops of this country; while the larvæ of the *Tortrix vitana* attack the vines of France.

Section VII.—The TINEÆ are small moths, distinguished by their bristle-shaped antennæ, and narrow, elongated, fringed wings, which are usually folded together when in repose. The majority of the larvæ live upon vegetable matter, mining their way into leaves, where they find ample shelter and nourishment; the leaves showing their winding galleries only on one side. The clothes-moth larva is notoriously destructive to woollen materials of every description; feathers, furs, skins, and similar substances are devoured by others, the materials being also used for the construction of their cases, in which, when full-grown, they become chrysalids. Two species of *Galleria* infest bee-hives, feeding upon honey, and forming galleries in the honeycomb.



Larvæ feeding on cloth.

The beetle and butterfly collections may be scientifically arranged by following the preceding classification of these two great orders of insects. But, after all the rules for the preparation of natural history specimens have been observed, a diligent and careful supervision of the collections is indispensable.

The boxes or cabinet drawers in which the insects are kept should totally exclude the light when they are closed, as sunlight, or even ordinary daylight, injures the colours, and causes the bright fresh hues to fade. They should also be tightly fitted, so as to exclude dust and mites, and should be lined with cork a quarter of an inch

thick, having white paper pasted on its surface. Camphor must be kept in the drawers and boxes, and replenished as it evaporates.

When mites once get into a collection they make sad havoc in it. Their presence is easily detected by the accumulation of little heaps of brown or white powder under the bodies of the specimens. If the objects attacked are common and easily replaced, the best plan is to throw them into the fire; but if they are rare and valuable species, the drawer containing them must be inverted over a piece of cloth saturated with naphtha for one hour or more. The fumes from the naphtha will effectually destroy the mites without injuring the specimens.

It is difficult to prevent the entrance of mildew into the collections, but keeping them in a dry warm room is a preventive. The neighbourhood of an oven is hurtful; but a dry, cold wind on a fine sunny autumn day will evaporate damp and completely dry the insects. Mildew can be easily removed from beetles by brushing the insects with pure alcohol.

After a time, the bodies of many insects exude an oily or fatty matter, which spreads to the wings, thorax, and finally to the paper, and thus spoils the appearance of cabinet and boxes. Insects in this condition may be cleaned by immersion in benzoin or naphtha, and afterwards sprinkling them with finely-prepared chalk or magnesia, which absorbs the grease; remove this, when the insect is dry, with a camel's-hair brush.

The Lepidarium.

This is a collection of butterfly impressions, obtained from the powder on their wings in the following manner: spread a thick solution of gum arabic over a sheet of fine paper, so that it readily adheres to the finger. Take off the wings of a dead butterfly, and lay them carefully on the gummed paper, spread out as in the act of flying. Place another sheet of paper over the wings, and rub them gently with the finger, or the smooth handle of a knife. The wings will then be left on the paper. Afterwards draw the form of the body, with the head and antennæ in the space between the wings.

AN OUTLINE SKETCH OF THE INSECT ORDERS.

For Young Collectors.

Most young insect collectors give their time and attention exclusively to beetles and butterflies, certainly the most striking to the eye of all the natural orders. They know, indeed, that there are wasps, hornets, bees, humble-bees, ants, and house-flies; gnats and gad-flies are sufficiently annoying, both at home and in their expeditions, to make them aware of their existence; locusts are met with in the field, and crickets in the house; in summer-time dragon-flies may be seen in active pursuit of gnats; and mosquitoes and other insects may be noticed flying to and fro over the surface of their native swamps,—but only superficial thought is given to these samples of the other orders of the insect kingdom. Although the insects belonging to these orders are not so attractive in form and colour as beetles and butterflies, they claim some share of attention, if it is only for the wonderful instinct which they display in providing food for themselves and their offspring, and in the construction of their various works. It is well, therefore, that something should be known of these orders, and of the insects belonging to them, which are occasionally included in the sweep of the bag-net. And, though no regular collection is made, samples of the insects and their works may be placed in the cabinet. The order and family to which an insect belongs should be known, and the larva and changes (complete or otherwise) through which the insect passes recognised,—all of which will be found most instructive and interesting.

It has been shown that all insects, in their development from the egg, pass through a series of changes. The degree of these changes is, however, very different in the various orders of insects. In beetles, butterflies, and moths (Coleoptera and Lepidoptera), the metamorphosis is complete, the larva, pupa, and imago constituting three distinct phases of life. In other groups of insects, as in the dragon-flies (Neuroptera) and grasshoppers (Orthoptera), the transformation is more gradual, the larva, pupa, and perfect insect resembling each other, or the metamorphosis is incomplete. The class

Insecta is, therefore, according to Dr. Carpenter (whose numbering of the Linnæan orders is here adopted), divided into two leading sub-classes, according to the different degrees of transformation, under the names of complete and incomplete metamorphosis.

Sub-class 1. *Insects having a sudden and complete metamorphosis.*

ORDER IV.—MEMBRANE-WINGED INSECTS (*Hymenoptera*).

The HYMENOPTERA (Greek, ὑμήν, a membrane; and πτερόν, a wing) have four wings, transparent, membranous, and the veins few—the hinder pair smaller than the others. The mouth is furnished with powerful horny jaws, and the females are armed with a many-valved sting or ovipositor. This enormous order is divided into two groups, or sub-orders, and these again into six families.

Sub-order 1. The *Terebrantia*, or *Borers*, are stingless insects, the females characterised by the possession of an ovipositor capable of perforating the substance of plants or the bodies of animals. This weapon is used, as its name implies, to prepare a suitable place in which to deposit the eggs, where the larva, as soon as it emerges from the egg, shall find itself surrounded by appropriate food. The larvæ somewhat resemble caterpillars, but differ from them in having twenty-two feet, instead of sixteen. In this sub-order there are two families.

1. The saw-flies (*Tenthredinidæ*) are so called from the saw-like character and action of the ovipositor. They cut numerous small slits in the leaves of plants, in each of which they deposit an egg, and close the hole with a drop of frothy fluid. Their larvæ feed upon the leaves and other soft parts of plants; hence their scientific name, *Phyllophaga*, or leaf-eaters.



Ovipositor of Saw Fly.

2. The borers (*Terebrantia*) are the type after which the sub-order is named. In this family the ovipositor differs in its structure from that of the saw-flies; it consists of three long and slender pieces, two of them forming a sheath for the third, all three being serrated at the

extremities. These insects perforate the bark and wood of trees, and often inflict much damage on timber, especially in those parts of Europe where pine forests abound. Their scientific name is *Xylophaga*, or wood-eaters.

3. The ichneumon flies (*Ichneumonidæ*) deposit their eggs in the bodies of other living insects, generally caterpillars, by piercing them with their ovipositors, which are straight and of variable length.



Ichneumon Fly depositing Eggs.

If the caterpillar to be attacked lives below the bark, the ovipositor is very long, and capable of penetrating almost any substance; while those ichneumons having short ovipositors place their eggs in caterpillars more easily accessible. In a few days the ichneumons are hatched as footless grubs, which devour the fatty portions of the caterpillar without injuring any vital part, so that the larva thus infested still continues to live and supply them with nourishment. When the ichneumons are ready to undergo their final change, they pierce the skin of their caterpillar prison, and become pupæ, in a few hours enveloping themselves in a clear, yellow spun yarn. The cluster thus formed on the body of the caterpillar is sometimes falsely called caterpillar's eggs.

After a time the perfect ichneumon flies emerge from these chrysalids, leaving the perforated skin of the caterpillar behind

In autumn, this process may be easily observed in the caterpillar of the common white or cabbage butterfly. The perfect ichneu-



Male and Female Ichneumon Flies.

mons are useful, active insects, feeding on the juices of flowers, and constantly hunting for caterpillars in which to deposit their eggs. In this way countless millions of larvæ are annually destroyed by them. Their scientific name is *Entomophaga*, or insect-eaters.

4. The gall-flies (*Cynipidæ*) puncture the leaves and branches of trees with their ovipositors, inserting an egg in each hole. The consequent irritation of the surrounding surface causes the growth of those well-known excrescences on the leaves of the oak which are called oak spangles or oak galls, and on the branches of the rose bedeguar or hairy galls; these products nourish the larvæ which they invariably contain. If one of these galls be cut through the centre, the small white grub will be easily detected. The gall of the rose has an agreeable acid flavour, and it is therefore often eaten by boys who are not aware of the presence of the grubs inside. Galls are of different degrees of consistency. The hardest known is the common gall-nut of commerce, which is produced on the leaves of an oak growing in the Levant (*Quercus infectoria*), and is employed in the manufacture of ink and in the process of dyeing. The "apples of Sodom," which are found on the borders of the Dead Sea, are only soft galls, which appear beautiful to the eye, but turn to ashes on the lips. When the insect has escaped, a circular perforation is visible on the surface of the gall.



Oak Galls.

Sub-order 2. The *Aculeata*, or Stinging Hymenoptera, have ovipositors resembling an *aculeus*, or prickle, which not only deposit the eggs, but also convey a poisonous fluid into the wounds which they inflict. These Aculeated Hymenoptera are divided into two groups or families.

The solitary and social predaceous wasps (*Prædones*), solitary

insects such as wood-wasps (*Crabronidæ*), sand-wasps (*Ammophila*), mud-wasps (*Pelopæus*), and social wasps and hornets (*Vespa*), are all insects which sting painfully if molested, and sometimes prove troublesome through their fondness for sweets. Yet, as they feed themselves and their offspring not only with the honey of flowers, but with the softer parts of insects, which they destroy in vast numbers for this purpose, their occasional trespasses may well be forgiven. The ant, so well known for its industrious habits, and which is mentioned in Scripture as an example of diligence,[1] belongs to this group of insects. Very wonderful are the communities of ants, wasps, and bees, and the nests which are erected in common by them, in which the larvæ, all sharing alike, are kept and fed.



Wasp.

The solitary and social bees (*Apidæ*) live wholly on the honey and pollen of flowers, and feed their young on a mixture of the same, called bee-bread. The habits of both solitary and social bees are very interesting, and will well repay investigation. The nests of the solitary carpenter-bee (*Xylocopa*) are constructed in rotten wood, are entered by a circular hole, and consist of from eight to twelve cells, in each of which an egg is deposited, with a quantity of honey and pollen, as food for the future larva. These cells are formed in succession, and are separated from each other by walls of sawdust. The whole structure may easily be laid bare by cutting through the wood. This bee is unknown in England, but is common in France, the southern parts of Europe, and in the United States of America.



Paper-making Hornet.

The mason-bees (*Osmia*) form their nests of grains of sand,

[1] Prov. vi. 6.

cemented together with a glutinous secretion, and place them sometimes in the ground, or on the angle of a wall, or in a crevice between bricks.

The upholsterer-bees (*Megachile*) form their nests in the interior of decayed trees, lining them with circular pieces of leaves, clipped off by means of their powerful jaws, which are used like a pair of scissors. These fragments of leaves (usually of the wild rose) are so admirably fitted that, although not coated with gum, they are honey-tight. These little architects, without scale or compasses, mete out the materials of their work into portions of an ellipse, into ovals and circles, and then join the pieces with the most perfect accuracy, not making a single mistake.



Rose-leaf-cutter Bee and Nest.

Thus even human art and reason are excelled by the teaching of the Almighty. Indeed, the accurate instruments and complex machinery of man go no further than the imitation of forms which exist around him, or which have been produced with consummate skill by inferior creatures. The original device is Divine, the copy is human. We should therefore be ready to recognise the designs and works of God everywhere, and to acknowledge how imperfect is our best performance when compared even with His lowlier works wrought by His inferior creatures.

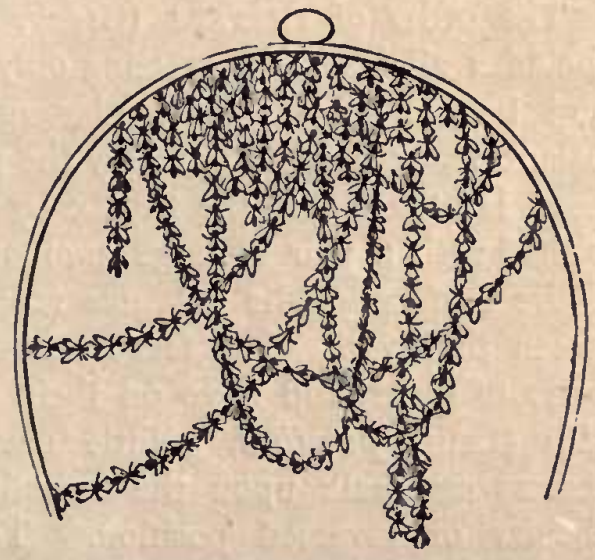
There are several species of upholsterer-bees besides the *Megachile*, or rose-leaf-cutter. Only one can be mentioned here, the poppy upholsterer (*Apis papaveris*). This species, says Réaumur, "invariably chooses for the hangings of her apartments the brilliant scarlet petals of the wild poppy, which she dexterously cuts into the proper form."

The social-bees (*Apidæ*) consist of two principal groups, the

well-known humble-bees (*Bombi*) and the honey-bees (*Apis mellifica*), to whose proverbial industry we are indebted for our annual supplies of honey and bees'-wax. The humble-bees construct their nests of moss, which are situated under the surface of meadows and pastures. These insects are easily recognized by their large size and hairy bodies, which are often black, with yellow or orange bands. They usually form communities of from fifty to sixty individuals. The cold weather, however, kills all but a few females, who alone survive the winter. During the first fine days of spring these females commence rebuilding, and furnish their nests with pollen and honey. The honey is neither so fine nor so good, nor is the wax as clean or as easily melted as that of the hive-bee.

The honey-bee is the species which is the most interesting and important. In the natural state these invaluable insects generally construct their nests in hollow trees; but they are rarely found wild, being now almost universally hived or domesticated. It is a remarkable fact that we derive the greater part of our knowledge of the economy and habits of the hive-bee from the labours of a blind naturalist named Huber, who lost his sight when only seventeen. He kept bees in glass hives, and, aided by his wife, became acquainted with all that went on in them. Through her faithful description of what she saw, and her labours as his secretary, Huber collected the materials of his celebrated work.

The societies of the honey-bee, consisting generally of about twenty-two thousand individuals, are permanent, and survive the winter. The stores of honey which they collect are intended to support them through that period. We cannot enter fully into the details respecting the construction of the comb, with its beautiful hexagonal cells, the collection of honey and other stores, and the general govern-



Festoons of Bees secreting Wax.

ment of the hive. The eggs are laid, the larvæ are hatched, and the honey is stored in the cells.



Queen Bee.

There are three kinds of bees in every hive — the queen, the workers, and the drones. In every hive there is one queen, with about two thousand drones, and about twenty thousand workers. The queen lays the eggs, the workers construct the cells and collect the honey and pollen, and the drones act as attendants on the queen, but do not gather any honey. Further particulars will be found in Mr. Newman's *Familiar Introduction to the Study of Insects.*



Worker.



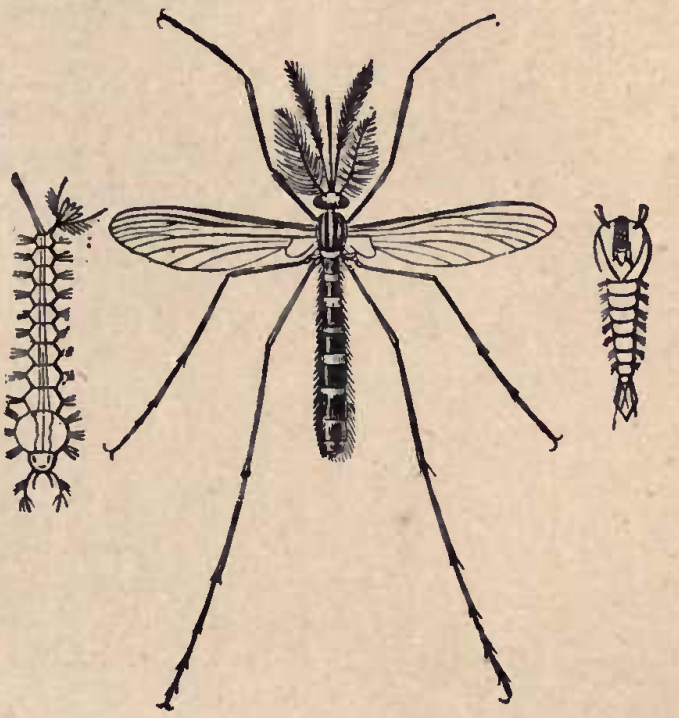
Drone.

Order VIII.—Two-winged Insects (*Diptera*).

The order of Diptera (Greek, δίς, double, and πτερόν, a wing) includes all insects possessing only one pair of membranous wings, and behind them two slender moveable bodies, termed *halteres*, balancers, or poisers, probably the rudiments of a second pair. The head is attached to the thorax by a very narrow neck, and is furnished with a pair of large compound eyes, which cover nearly its entire surface. The antennæ are placed in front of the head between the eyes. The feet or tarsi are five-jointed, terminated by pairs of claws, and have on their under surfaces two or three pulvilli (Latin, *pulvillus*, a little cushion), by means of which the insects can walk upon the smoothest surfaces, even in a perpendicular or reversed position. The common house-fly and the common bluebottle-fly well represent the above features of the

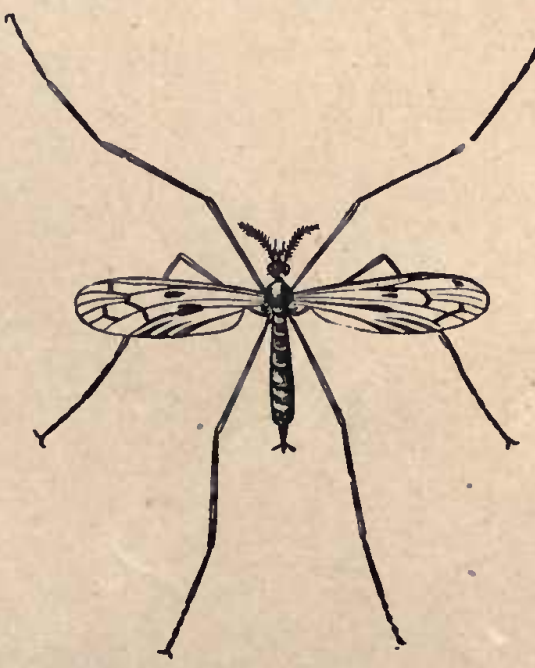
Diptera, and may usually be found on the window-panes or walking about the ceilings of our rooms.

The larvæ of these insects are generally white, cylindrical, footless grubs, and live on putrescent matter of all kinds, both on land and in water; they may also be found in galls, caterpillars, and living animals.



Caterpillar, Chrysalis, and Imago of Gnat.

We can only enumerate here the four sub-orders, and their most characteristic families: I. The NEMOCERA (Greek, *νῆμα*, a filament; and *κέρας*, a horn) have filamentous antennæ, either beautifully tufted or feathered, composed of more than six joints. This division contains only two families: 1. The gnat family (*Culicidæ*) have mouths not only adapted for sucking, but they are also furnished with lancet-shaped organs for piercing the skin. Stinging gnats of various species abound in damp or marshy ground, and are bred from aquatic larvæ. Hundreds of *Culex pipiens*, and other closely-allied species, may be seen dancing in the air on a summer's evening. To this family belongs the bloodthirsty mosquito of southern climates (*Culex mosquito*), from which this country is, happily, comparatively free.



Crane Fly.

2. The crane-flies, or daddy long-legs (*Tipulidæ*) are common

in meadows, and are easily recognised by their long legs. Though harmless as flies, they are very injurious in their larval state; for they devour the roots of grasses, sometimes entirely stripping fields of their herbage.



Spiracle of Chamæleon Fly.

II. The NOTACANTHA (Greek, *νῶτος*, the back, and *ἄκανθα*, a spine) generally have the back of the thorax armed with teeth or spines. The perfect insects of this sub-order are mostly small and gaily-coloured, feeding on the juices of flowers, and are found in moist situations. Some of the larvæ—for instance, that of the chameleon-fly (*Stratyomis chamæleon*)—respire, like the larvæ of gnats, through their tails, where the spiracle or breathing-orifice is situated. This spiracle is furnished with a circle of bristles, to prevent the water from rushing into it, as the insect rises to the surface to breathe.

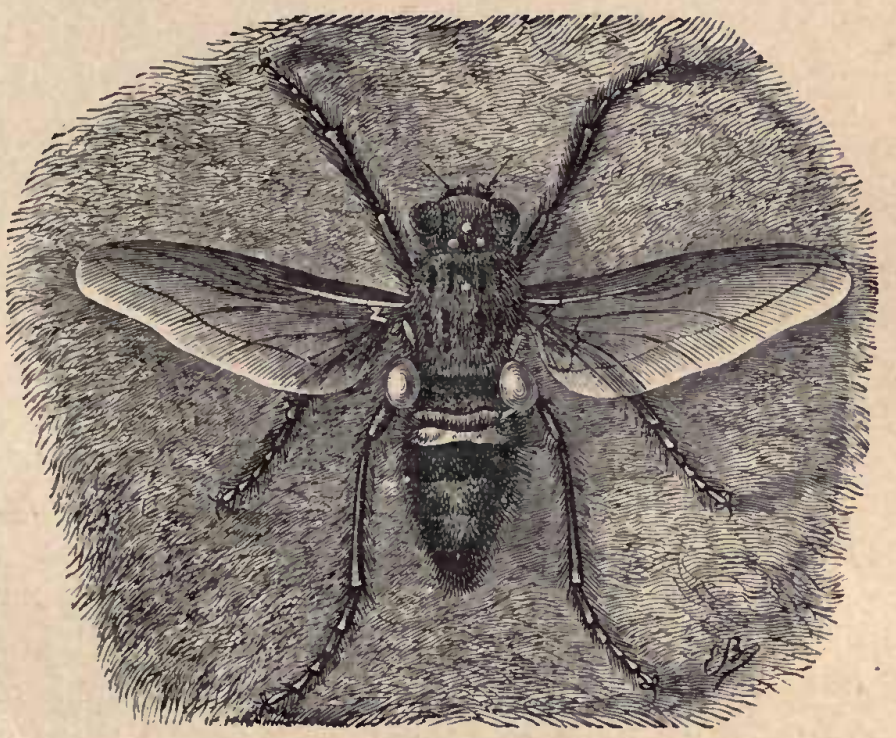
III. The TANYSTOMA (Greek, *τείνω*, I stretch, and *στόμα*, a mouth) comprehends all those Diptera which have a projecting proboscis, with the last joint of the antennæ undivided. The well-known gad-flies (*Tabanidæ*), which are such an annoyance to man and beast, belong to this sub-order. The proboscis is fitted both for piercing and sucking, performing the double office of inflicting the wound and pumping up the blood. Another member of this sub-order is the hornet-fly (*Asilus*), which preys on other Diptera, catching them on the wing, and sucking their vital juices. Another family is the *Bombylidæ*, consisting of hairy flies resembling small humble-bees; they are dis-



Tsetse Fly.

tinguished by the length of the proboscis, with which they suck the nectar of flowers. Whilst hovering over the blossom the motion of their wings is so rapid that for the moment they appear to be stationary; then suddenly they dart to another flower so quickly that the eye cannot follow them.

IV. The ATHERICERA is a sub-order of Dipterous insects characterised by the possession of antennæ having only two or three joints, and a proboscis capable of being withdrawn within the mouth. Some of the family live upon the honey of the flowers which they frequent. When flying in the bright rays of the summer sun the perfect insects are beautiful in appearance and dainty in their food; yet the larvæ are bred in the vilest filth, and are known as rat-tailed maggots, and are as dirty in their habits as they are repulsive-looking.



Bot Fly.

These remarks are especially applicable to the first family of this sub-order, the bee-flies or *Syrphidæ* (Greek, *συρφετός*, filthiness), so called from their place of birth—filthy water. Other families are carnivorous, like the bot-flies (*Œstri*). These insects deposit their eggs on the bodies of various domestic animals. In the case of the ox, the larvæ produce the well-known tumours called bots. Another species infests the horse, and fixes its eggs on the parts most likely to be licked by the animal, so that he is made instrumental in conveying his foes into his own intestines. There the eggs are hatched at a temperature of 100°, and the larvæ are furnished with rings of

bristles, which help them to maintain their position. The larvæ undergo their final transformation in the dung of the animal which they have left.



Blow Flies.

The common house and flesh flies (*Sarcophaga*) belong to the *Muscidæ*, and render important service to mankind, when in the larval condition, by assisting in rapidly clearing away carrion, the slow decay of which would otherwise taint the air and render it unwholesome. In a similar manner, the larvæ of the gnat, of the drone-fly (*Eristalis*), and of the *Syrphidæ*, tend to purify the marshes and sewers where they are bred, by devouring the putrescent matter abounding in those places. They act as scavengers of the water, lessening the poisonous exhalations of the marsh; while the insect-scavengers of the land keep the air pure by burying or devouring the carrion found there.

Insects thus perform their appointed tasks in the economy of nature, each species being adapted to the performance of its own kind of work. In truth, we meet in nature with innumerable illustrations of the Divine adaptation of means to ends. They occur in circumstances which forbid our referring them to the operation of natural laws alone. There *are* laws; there is a great law of design, and there is another great law of adaptation of means to carry out that design. But laws are not self-originating and self-working. There is a Law-giver and Law-administrator, who is above the laws, who controls them, and makes them effective in operation by means of His creatures. The laws of nature are the laws of God. The arrangement by which insects and other creatures perform their allotted tasks has been made by God. The instincts and special organs by which they work are given them by the great Creator. All are the products of His wisdom and skill. We may therefore well exclaim with the Psalmist, "O Lord, how manifold are Thy works! in wisdom hast Thou made them all."[1]

[1] Psa. civ. 24.

Sub-class II.—Insects having a gradual and incomplete Metamorphosis.

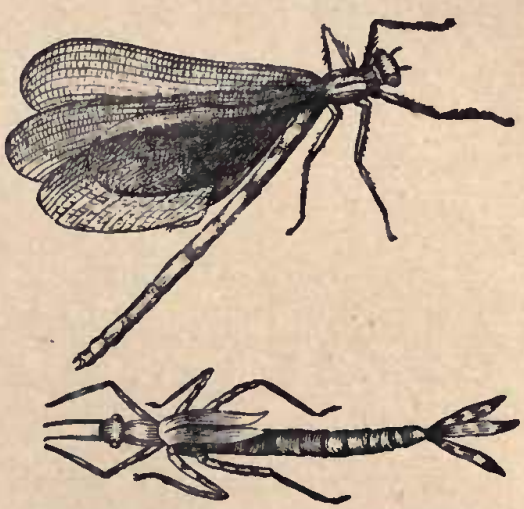
The larvæ and pupæ of this sub-class more or less resemble each other, and the perfect insect is without wings. The pupæ are generally active, and continue to eat in that state; but in some cases they are quiescent, although still retaining the power of motion. The following orders are included in this sub-class.

Order III. NERVE-WINGED INSECTS (*Neuroptera*).

These insects have four large, equal-sized, membranous, and transparent wings, furnished with a network of numerous longitudinal and transverse nerves. The body is cylindrical, jointed, elongated, soft, and very beautifully coloured, steel-blue, orange, or yellow, and iridescent. The head is furnished at its sides with two large compound eyes, and also has three simple eyes arranged in the form of a triangle on its upper surface. The antennæ are bristle-like, the jaws fitted for biting or chewing, the legs six in number, and the tarsi three-jointed. The dragon-fly (*Libellula*) is a well-known representative of this order. Some of the dragon-flies have their wings expanded horizontally when in repose; while others (*Agrion*) have them closed and vertical. The eggs are laid on the leaf or stem of some aquatic plant. The larvæ are dark and repulsive-looking, and resemble the perfect insect deprived of wings; they move about the bottom of their native pond, and feed on aquatic insects and worms. When the time for leaving the water has arrived,



Dragon Fly, with wings expanded horizontally

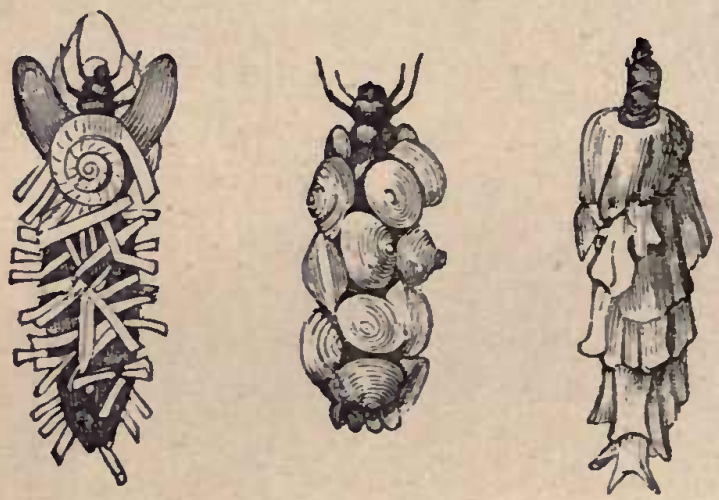


Dragon Fly, with wings vertically closed, and Larva.

the larva crawls up the stem of some aquatic plant, where it becomes stationary, and changes into a pupa closely resembling the larva. The dragon-fly ultimately emerges from the pupa state, and, after drying and expanding its wings, commences its atmospheric life. It is now a brilliant, active creature, loving the sunshine, and perpetually on the wing, hunting after living insects, which it captures flying, and then it settles on some twig and leisurely devours its prey. The dragon-flies seldom leave their native marsh or stream, but continue flying about its surface, feeding on the gnats, mosquitos, and other insects abounding there until they are captured and devoured themselves by a swallow, robin, or some other insectivorous bird. The beautiful lace-fly (*Hemerobius*), the short-lived may-fly (*Ephemera*), the scorpion-fly (*Panorpa*), and the caddis-fly (*Phryganea*), all belong to the *Neuroptera*.



May Fly.



Larvæ of Caddis Flies in their Cases.

Order II.—Straight-winged Insects (*Orthoptera*).

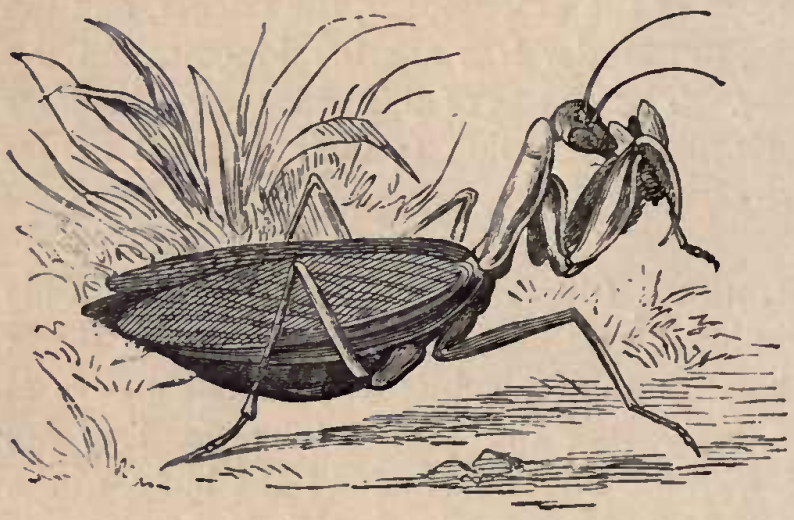
The order of Orthoptera (Greek, *ὀρθός*, straight, and *πτερόν*, a wing) consists of insects having two pairs of dissimilar wings; the front pair are smaller than the hinder, and are usually of a leathery or parchment-like texture, and serve as a protection for the latter, which are membranous, and when in repose are folded up longitudinally in a fan-like form beneath them. The head is large, and is furnished with

two small and two large compound eyes. The mouth is unmistakeably formed for biting. The antennæ are generally long, and have numerous joints. The legs are formed either for running, as in the cockroach, or for leaping, as in the grasshopper, the cricket, and the locust. In the last case, the hinder legs are the longest, and the thighs of considerable size. The insects of this order have therefore been classed in two sub-orders, according to their different modes of progression.

Sub-order I. The RUNNERS (*Cursoria*) have legs of the same length, adapted for running or walking. The withered-leaf insect (*Phyllium siccifolium*) belongs to this sub-order. It is a native of India and of the warm regions of the East. The six legs are nearly of the same size, with the thighs expanded; the body, wings, and thighs have a leaf-like appearance, so that the insect closely resembles the leaf on which it feeds. It also undergoes changes of colour corresponding with the seasons, passing from the beautiful deep green of the foliage of early summer to the "sere and yellow leaf" of autumn. In the collection in the British Museum there is a case containing walking-leaf insects from Brazil, in which not only the colour of spring and autumn leaves is imitated, but also the attacks of insects on the foliage. The object of these curious imitations of nature cannot be misunderstood: it is to give these insects the means of escape from their natural enemies. The care and goodness of the great Creator over all His works are thus made manifest. Nothing is trifling or beneath the notice of Him who "clothes the grass of the field with grand array." Kindness and care for others, even for inferior creatures, should, therefore, be always exhibited by us, as we strive to follow in His steps who "went about doing good."

Of other closely-allied tropical insects we may mention the walking-sticks (*Phasmidæ*), which are of a dingy, brownish colour, exactly resembling the dried twigs of a tree. The praying mantis (*Mantis religiosa*) is also in form and colour very much like the leaves and twigs among which it lives, so that it easily escapes notice. These insects are of a beautiful green colour, and are distinguished by the

structure of their forelegs, which are larger than the others, being powerful organs for seizing the prey. This at once shows that this insect lives by attacking others. When the two forelegs, which are armed with numerous spines, are held up, the attitude is that of a person at prayer; but really this posture is most convenient for the capture of its food. All the insects belonging to this sub-order, however, with the exception of the *Mantidæ*, which, as previously stated, feed on insects, are very destructive to vegetation.

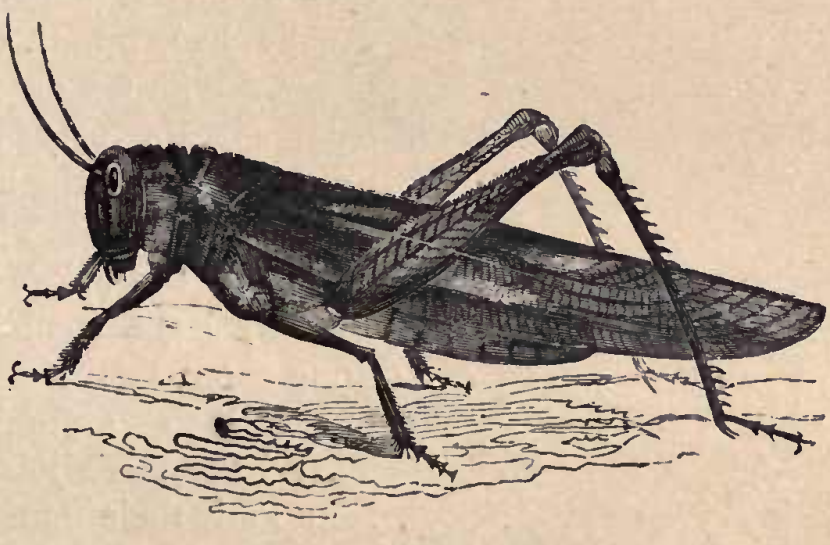


Praying Mantis.

Sub-order II. The LEAPERS (*Saltatoria*) have legs of disproportionate length, the hindermost being much the largest and strongest, and fitted for leaping. This sub-order comprises numerous well-known insects, such as the common house-cricket (*Acheta domestica*); the grasshopper (*Gryllus viridissimus*), of large size and splendid appearance in foreign countries; and the locust, of which comparatively few are found in temperate climates, although it is unhappily abundant in warm countries. Perhaps no individual of this sub-order is so well-known as the common cricket. These noisy little denizens of the fire-side have the antennæ slender and tapering, and the hinder wings long and projecting beyond the fore-wings in the form of a pair of tapering tails. In summer they forsake the fire-side for the garden or the crevices of its walls, as they then find heat enough outside. In autumn, when the weather gets cold and damp, they come into the house and renew their song at the fire-side, which they continue through the winter months; but, should the fire be discontinued, their song ceases,

and they become torpid and inactive. The house-cricket seeks the society of man, feeding on bread-crumbs, milk, gravy, and kitchen refuse; but the field-cricket (*Achēta campestris*) avoids human society, living all the year round in burrows in sandy banks. The mole-cricket (*Gryllotalpa vulgaris*), a still rarer British insect, has fore-limbs turned outwards like the hands of a mole, and which are powerful digging organs. This cricket is constantly engaged in burrowing, and is said to live quite as much on animal as on vegetable food.

There is one more insect belonging to the present order, the locust, of which we have several British species of small size. These locusts are, however, nothing like so large or so destructive as the foreign species known as the migratory locust (*Locusta migratoria*),



Locust.

which is the terror of Eastern countries. These locusts fly in such immense numbers that they darken the heavens and hide the light of the sun. If a swarm of these insects settle, they devour every green thing, and only leave the spot when the destruction is complete. In fact, when the swarm has taken its flight elsewhere, the country appears as if it had been burnt with fire; hence the Latin name of this insect, *Locusta* (from *locus ustus*, a burnt place), is peculiarly appropriate, on account of their voracity. The descent of a hostile army is less dreaded by the inhabitants of Eastern countries than a flight of locusts.

Order VII.—Half-winged Insects (*Hemiptera*).

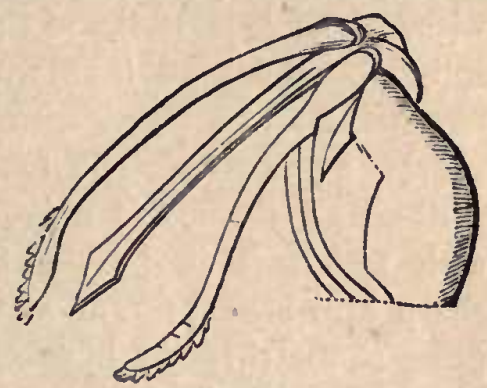
The Hemiptera (Greek, ἥμισυ, half; and πτερόν, a wing) have the wing-covers of a consistence intermediate between the elytra of beetles and ordinary membranous wings. The larvæ are small, have six feet, and differ but little from the perfect insects, save in the absence of wings. The pupæ are active, and are distinguished by having wings and elytra concealed in small dorsal cases. This order is divided into two sub-orders.

Sub-order 1.—The Homoptera (Greek, ὁμός, the same; and πτερόν, a wing) have wings of an uniform semi-membranous consistence, which do not overlap each other. The perfect insects usually live on the juices of plants. With few exceptions, the antennæ are very short, and bristle-like; and the body is convex and thick. The Cicadæ belong to this sub-order. They are very large, sometimes measuring more than six inches between their expanded wings. They have three joints to their feet, and their mouth is also three-jointed and very long, being tucked under the body when not required. The females are furnished with spear-like ovipositor or auger, by which they can cut grooves in branches of trees, for the purpose of depositing their eggs. The female deposits between six and seven hundred eggs. As soon as hatched, the young make their way to the



Cicada.

ground, where they resemble the common flea in size and shape. In winter they sometimes burrow into the ground to the depth of a yard. The male insect has the power of making a shrill sound for several hours without intermission. The apparatus producing this consists of two drum-like membranes and a set of powerful muscles, situated underneath the body, just behind the last pair of legs. One species (*Cicada Anglica*) is to be found in the New Forest, but generally they are tropical insects. To this family belong, in addition to the lac and cochineal insects of commerce, the plant-lice (*Aphides*); the frog-hoppers (*Cercopidæ*), of which the cuckoo-spit of the gardens is a well-known example, the larva enveloping itself in their frothy secretion which clings to plants, in the midst of which it may be found; the lantern-fly, a luminous insect of South America (*Fulgorina*); and the remarkable seventeen years' locust of the United States (*Cicada septemdecim*), which continues for that period in the larval state, although its existence lasts for only a few weeks after it has undergone its final transformation.



Auger of Cicada.

Sub-order 2.—The HETEROPTERA (Greek, ἕτερος, various; and πτερόν, a wing) have four wings, the basal portion of the front pair being horny, and the remaining part membranous. In some species, however, the wings are wanting, as in the common bed-bug (*Cimex lectularius*). The body is always much flattened, the mouth is beak-like, and in the pupal state the creature is active, and resembles the perfect insect, except in its want of wings. Many of the sub-order are aquatic, and are dull black or brown in colour; while the terrestrial species, especially those belonging to the tropics, glow with all the colours of the rainbow. It is remarkable that almost every terrestrial species is capable of emitting a very powerful odour, in most cases extremely unpleasant, but in others rather agreeable. The odour is usually exhaled when the insect is touched or alarmed, and is quite under its control.

The Back-swimmers (*Notonectidæ*) are common in England, the water-boatman (*Notonecta glaucus*) being the one most frequently met with. The insects lie on their backs in the water, and propel themselves by the hind legs, which are very long, with the extremities expanded and fringed with hairs, and which have an oar-like appearance and use. The breathing apparatus is situated under their wings, and the air is prevented from escaping by the stiff hairs with which it is provided. The beak of all this family is very sharp and strong; and a heedless captor will often feel a sudden pang shoot through his fingers, caused by the spear-like, deeply-jagged insect's beak. The wings of the water-boatman are large and handsome, and the insects are powerful on the wing. The common bed-bug also belongs to this sub-order, as well as the water-scorpion, the loose-neck (*Reduvius*), the water-measurers (*Hydrometridæ*), and the plant-bugs (*Pentatomæ*).

All these insects, including the Orthoptera and Neuroptera, should be pierced through the thorax with a pin dipped in oxalic acid, which will speedily kill them. The wings of the larger kind should be displayed like those of butterflies and moths, and the smaller species mounted on triangular pieces of card.

It is very desirable that collectors should have, in one of the drawers of their cabinet, good typical specimens of the leading orders of insects, and also of the *Arachnidæ*, or spiders, and *Myriopodæ*, and such-like closely-allied forms, so as to be able to recall to their memory at a single glance the arrangement of this part of the animal kingdom.

We cannot do more, however, than refer to this extension of the subject. Fuller authorities must be consulted by those wishing to enlarge their researches. If the collector has succeeded in securing most of the specimens mentioned in this section, he will have formed extensive and instructive collections of beetles and butterflies. The more he becomes acquainted with even the minute works of God, the more plainly will be seen the wisdom, power, and goodness of the great Creator; and the manifestation of these Divine attributes should awaken devout and grateful feelings in every thoughtful mind. To study the works only, and stop short

of the great Worker Himself, would be idolatry; rather let us study them in conjunction with that written word which is able to make us unto salvation, through faith which is in Christ Jesus—seeking the guidance of the Holy Spirit who inspired holy men of old to write it. Such double study will both minister to our temporal enjoyment and promote our eternal interests.

"The Invisible in things scarce seen revealed,
To whom an atom is an ample field:
To wonder at a thousand insect forms,
These hatched, and those resuscitated worms,
New life ordained, and brighter scenes to share,
Once prone on earth, now buoyant upon air;
Whose shape would make them, had they bulk and size,
More hideous foes than fancy can devise.
These are Thy glorious works, Thou Source of good!
How dimly seen, how faintly understood!
Thine, and upheld by Thy paternal care,
This universal frame, thus wondrous fair;
Thy power Divine, and bounty beyond thought,
Adored and praised in all that Thou hast wrought.
Absorbed in that immensity I see,
I shrink abashed, and yet aspire to Thee;
Instruct me, guide me to that heavenly day,
Thy words, more clearly than Thy works, display,
That, while Thy truths my grosser thoughts refine,
I may resemble Thee, and call Thee mine."

COWPER.





Section IV.

THE PLANT COLLECTION.

THE HERBARIUM.

As already intimated, some knowledge of botany is necessary for the proper study of insect life; for the different stages of the metamorphosis of insects, from the egg to the imago, or perfect form, can only be intelligently understood and appreciated by a thorough knowledge of the plants on which so many of them exist. Apart from this, however, the study of botany is not merely a pleasure,—it furnishes also a most instructive series of facts and observations at all seasons of the year. There is always to be found in this country, in winter, the lowly but beautiful tribe of flowerless plants, consisting of mosses and lichens. During spring and summer, commencing with the appearance of the first blossoms, a number of healthy and agreeable excursions may be made in search of wild-flowers, mosses, and ferns, and much happy time be thus spent in intercourse with nature. The interest taken in this study will deepen as the collection grows,

and the knowledge of the various plants increases. The business of collecting may be continued in golden-tinted autumn, and even until the year is drawing to its close, the winter snow has fallen, and only the native evergreens, hardy ferns, and flowerless plants remain.

After some progress has been made with such a collection, and a little knowledge acquired of botanical names, it will be found a pleasing and profitable occupation during the leisure of the long winter evenings to arrange the plants in a herbarium. The gratification found in this arrangement will be proportionate to the pains which have been taken to secure good specimens. While the weather without is rough and boisterous, and the roaring of the storm is heard through the leafless trees, the leaves of the herbarium may be turned over, amidst the comforts within doors, recalling many a pleasant ramble taken when the woods were in full foliage, the skies bright and clear, and the flowers blooming everywhere. It is true that these children of the woods are dead, their bright colours have faded, and they have been dried and pressed out of their fair proportions; but, after all, if carefully mounted and properly arranged, they are true pictures of the living plants, and far exceed even the best drawings in accuracy and beauty.

How to Collect, and Where to find the Plants.

Plants are to be found everywhere in the greatest profusion and variety. From the summits of mountains, near the snow-line, on the hardest rock, and in the poorest soil, where their presence speaks of Him who built the everlasting hills, and tinted even weeds with beauty, they extend down the slopes into the valleys, spreading like a carpet ornamented with innumerable flowers. Close examination of this plant-carpet will show that its pattern is wondrously variegated, different forms being produced by the mineral or chemical changes of the underlying soil. In seeking to collect a great number and variety of plants it is necessary to explore many different habitats, as they are called, or places where plants naturally grow. Shady woods, open fields, exposed roadsides, the dry and scanty soil of uplands, boggy and swampy ground, the banks of rivers, and the sea-coast, have each their peculiar species of plants.

The collection of specimens becomes easy and pleasant to those who bear in mind the ever-varying ingredients, moisture, and depth of soils. How much better and more satisfactory is even a little scientific knowledge than none at all; for the saying, "a little knowledge is a dangerous thing" is certainly not always true. A person totally ignorant of plants wanders through the country blind and indifferent to the marvellous works of God in nature. The forget-me-not by the brook, or the wild-rose in the hedge, may be recognized, and the taste of the wild strawberry or cherry may be familiar; but the animals or insects which feed upon them, and their medicinal or economical value is unknown.

Not much outfit is required by the plant collector, the following being the principal necessaries: a good field-book or local flora, containing a description of the plants in the district visited, a small gardener's trowel, a strong pocket-knife, a flower microscope, and a japanned tin box for holding specimens, with a lunch box at one end of it, and attached to the person by a strap, thus leaving the hands at liberty. The box should be convex, about eighteen inches in length, six inches broad, and three inches deep, and the lid should open nearly through its entire length, and fasten with a catch.

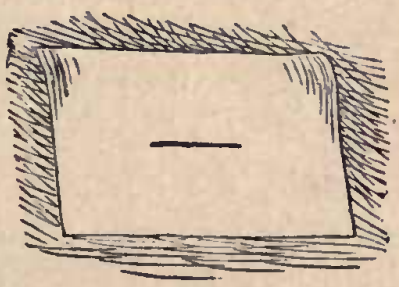


The Young Botanist.

In cases of cutting or trimming the specimens, the principal botanical features should be carefully preserved. The plants should always be put into the box quickly, to keep cool, and they may thus be carried home fresh and uninjured. A dry sunny day is best for gathering the plants, and on arriving at home they should be pressed and dried immediately; for the preservation of the natural colours of both foliage and flowers wholly depends on the rapidity with which this is done. Some botanists, however, prefer a collecting portfolio,

instead of a box; this usually consists of two stout boards containing about three quires of drying paper, between the leaves of which the plants are properly laid out as soon as gathered; the two boards being afterwards drawn tightly together by means of a stout strap. This plan has its advantages, for the plants are as well preserved as when the box is used, and are at once subjected to pressure, and on arrival at home are more easily transferred to the drying sheets.

Those who go out collecting plants accompanied by a botanist should be provided with tickets, upon which to write the scientific names of the specimens found. The tickets should be of stout white paper, rectangular, and have slits in the middle of them, through which the stems of the plants may be thrust. The tickets should bear the common and the scientific names of the specimens, the localities where they were found, and the day of the month when collected. Every plant should be correctly labelled before being placed in the box or the portfolio. The name should be verified by comparing the plant with the description given of it in the local flora, which should always be carried on botanical excursions. When a party are engaged in these researches, the members should scatter widely, as more specimens will be thus obtained, care being taken, however, to keep within call of one another, or some of the younger members may stray.



Plant Ticket.



Wood Anemone (*Anemone nemorosa*); Habitat, Berg, or Mountains of Germany; time of collecting, March 10, 1871.

On Pressing, Drying, and Mounting Plants.

To dry and press plants properly, it is necessary to provide two or more stout boards, having cross pieces at their ends to prevent warping, about a ream of good absorbent paper, and weights of not less than one hundred pounds. There must be plenty of paper, which thus becomes an expensive item. An excellent substitute, however,

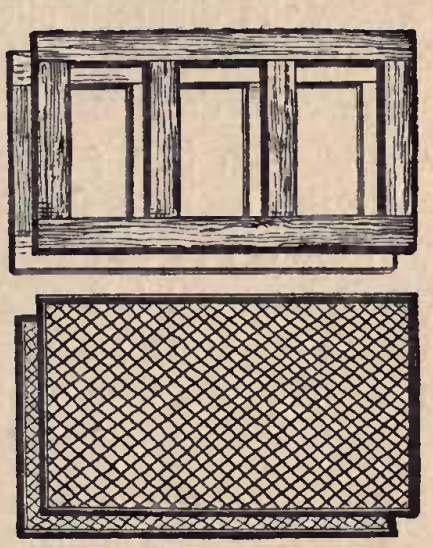
may be found in old newspapers, in which many a good herbarium has been dried.

The pressing should be done in the following manner: The plant should be laid out on a single sheet of paper, care being taken to set it out with as little confusion and disarrangement of its parts as possible. All unnecessary branches and leaves must be cut off, the flowers displayed, and the folded leaves laid flat. The specimen should especially contain those parts on which its generic or specific characters are founded. In some instances, therefore, it will be necessary to collect the root, as in the case of the common buttercup (*Ranunculus bulbosus*), and in other instances the fruit or pod, as, for example, the common shepherd's purse (*Capsella Bursa pastoris*), where the generic term *Capsella*, from *Capsula*, a capsule, refers to the fruit. In all cases the specimen should show not only the root and lower leaves, but the stem and upper foliage, with both flowers and fruit. In cases where the fruit arrives at maturity after the blossoms have all faded, other samples of the plant must be gathered later in the season. To equalise the pressure, the specimens should cover all parts of the paper. Where the stem is long and slender, as in the case of grasses, it must be bent and rebent upon itself, so as to bring the entire plant within the compass of the paper. Each bent portion must be kept in its place by insertion in a small slit made in a slip of paper. Over the plant thus spread out ten or twelve sheets of the drying paper must be placed. On the sheet that is uppermost another plant should be laid in the same manner, and covered with another half quire of paper. In this way the rest of the plants collected must be arranged, until all have been placed in the drying sheets.

The pile of plants thus arranged in layers is ready for pressing, which is done by placing one board at the top and the other at the bottom of the pile, and then fixing a heavy weight on the top of all. Good pressing will be greatly promoted by introducing thin boards at intervals between the sheets.

Another simple and inexpensive press consists of an upper and lower framework of board or wooden lattice-work, between which the paper is placed, the compression being produced by the

tightening of a stout leather strap. This press has the advantage of giving free access of air to both paper and plants. It may be hung before a kitchen fire, or exposed to the sunshine, thus ensuring the speedy drying of the plants.



Presses for drying Plants.

But, whether this press or simple weights be employed, in a few hours, the paper, which had become damp through absorbing a portion of the moisture of the plants, must be changed. This is accomplished by placing the sheets containing the plants between a fresh supply of dry paper, and subjecting them to greatly increased pressure. Care must be taken, however, not to disturb the specimens in doing this. The damp sheets should be spread out to dry, and when free from moisture are again fit for use. This process must be repeated until all the moisture is extracted from the specimens. Some plants—for instance, most of the fir tribe—in drying cast their leaves. This may be prevented by dipping them in boiling water before they are put in the drying sheets.

If the plants are kept too long in damp paper, their foliage blackens, and the blossoms lose their beauty. As a rule the paper should be changed at least twice on the first day, and afterwards once a day, the pressure being increased each time. Three or four days will be sufficient to dry most specimens; but where they are of a juicy nature a much longer time will be required. Thick roots, stems, and bulbs must first be divided lengthwise, and then thinned with a knife. The colours of blossoms likely to be lost in drying may be preserved by pressing the petals between oiled paper, and afterwards drying them with a warm flat-iron. When the plants cease to adhere to the drying sheets, and the paper itself is free from moisture, the process is completed.



Thinned Bulb.

Specimens in every stage of drying may be in the press at the same time, if thin wooden boards or stout millboards are interposed between the different piles; these prevent the moisture of a fresh collection spreading to the drier plants.

The collecting portfolio and strap are absolute necessities when the excursion is a prolonged one. At the first convenient opportunity the package should be unstrapped, the damp sheets taken out, fresh dry paper introduced between the plants, and the package strapped up afresh. The operation must be repeated morning and evening until the plants are dry. They should then be transferred to fresh paper, tied up loosely, and laid aside. In this way the specimens collected on a botanical excursion of several days' or even weeks' duration, may be brought home in a good state of preservation.



Mode of securing Plants.

The dried specimens are exhibited to advantage when mounted upon white, firm cartridge paper. The best size is seventeen inches by ten and a half. Each species should occupy a separate half sheet, and must be fastened to the paper with strong glue or by gummed strips of paper placed across the stem and branches. This may be prepared as follows: Cover one side of a sheet of paper with a strong solution of gum or glue, and spread it out to dry. The paper thus prepared should afterwards be cut into strips of the required size, and three or four of such strips moistened and placed across the stem and branches of a plant, if well rubbed down, are quite sufficient to fasten them firmly to the sheet. If each group of specimens has placed at its base a broad strip of red or blue paper cut into the shape of a flower-pot, the effect will be very pleasing.

The plan of fastening the plants by strips of adhesive paper is certainly better than the practice of securing them by gumming their entire surface. By the former method, if it be desirable to

transfer the specimen to another sheet, it is only necessary to cut the strips, and the plant is at once free from the paper, uninjured, and with very few stains upon its surface.

At the foot of the sheet should be written the scientific and common names of each plant, the place where it was found, and the day of the month when it was gathered. Where a specimen has been given, the name of the donor should also be recorded.

How to Name the Plants and Arrange the Herbarium.

Hitherto it has been supposed that help was at hand, and that it was only necessary to ticket the plants accurately before placing them in the collecting box. Such opportunities, however, do not occur every day; and it is therefore very desirable that the collector should be able to determine the scientific names of the specimens without assistance. The first steps in any science are always the most difficult and tedious, and for this reason the help of a teacher or an experienced botanist is invaluable, and a great saving of both time and study to the beginner on his earlier excursions. Nevertheless, sufficient information to create an interest having been once acquired in this way, an intelligent person will examine his own specimens, and try if he cannot determine their botanical names for himself. For this purpose a good book and a flower microscope are alike essential. Babington's *Manual of British Botany*, and Bentham's *Handbook of the British Flora*, are recommended for consultation.

The first thing to be done after bringing home a bundle of plants is to compare each specimen with the description given of it in the book. Bentham's *Handbook* gives the popular as well as the scientific names of all the common British plants, with drawings which are sufficiently accurate for all practical purposes. If the common name of the plant is known, the scientific name is easily found in the *Handbook*. The description of the specimen should then be studied, commencing with the root, stem, and leaves, and proceeding thence to the flower, the parts of which must be carefully dissected with pins, needles, or the sharp point of a knife, and examined with the flower microscope.

As before remarked, in order to secure complete specimens, it will be necessary to gather two examples of the same plant; for after the leaves and blossoms have been collected, it will be requisite to add samples of the mature ovary or seed-vessel later on. It is only by personal inspection and constant handling of the plants, and comparing what really exists in nature with the details given in books, that accurate knowledge of their properties, and of their position in the vegetable kingdom, is acquired.

But there are numerous plants without popular names, which have been noticed only by accomplished botanists, as, for example, *Lepidium Smithii*, described by Dr. Hooker, and *Caltha radicans*, first discovered and delineated by Mr. Forster. These can only be recognised after some knowledge, not only of structural, but of systematic botany, has been gained. The latter is an attempt to unfold and follow out that principle of order which exists in nature. Linnæus, who has been deservedly called "The Father of Natural History," has done excellent service in arranging plants. His artificial system, which is founded on the parts of the flower, is the best for beginners, and is, at the same time, an excellent introduction to the Natural System now universally adopted in our schools and universities.

After the season has been spent in diligently collecting, pressing, drying, mounting, and naming the plants, the formation of the *Herbarium*, or *Hortus siccus*, may be commenced. At the outset it will be advisable to select a room which will be free from disturbance; perhaps one at the top of the house will be the best. The room should have one or two chairs and a large plain deal table; it should also contain the press, boards, and drying papers; glue bottle, brush, cartridge-paper, sheets of adhesive paper, and scissors for mounting; penknife, needles, and microscope for dissection and examination; tickets, pens, and ink for labelling; and a few shelves for standard works on British plants, such as Withering's *British Botany*, Smith's *English Flora*, Hooker's *British Mosses*, Loudon's *Encyclopædia of Plants*, etc.

When all these arrangements are completed, the packages should be opened out on the table, and all the nameless plants separated

from the named and mounted specimens. All the specimens, both known and unknown, should at least have had noted on the tickets their place of growth, or habitat, and the day of the month when collected.

The unnamed parts of the collection should be set aside for future scientific examination; and the named and mounted plants arranged, according to the Natural System of Botany, into orders, genera, and species. The prominent natural orders, such as the *Ranunculaceæ* or Crowfoot family, the *Cruciferæ*, or Mustard family, the *Leguminosæ* or Pulse family, the *Rosaceæ*, or Rose family, the *Umbelliferæ*, or Parsley family, the *Compositæ*, or Composite family, the *Ericaceæ*, or Heath family, and the *Labiatæ*, or Mint family, should be placed in separate piles in the order indicated in Babington's *Manual* or Bentham's *Handbook*. Reference must be made to the index of the book consulted for the generic names of the plants whose natural orders are unknown.

After arranging all the specimens in orders, those containing the smallest number of plants should be collected together, for the sake of saving space. The orders must next be sorted consecutively into genera and species, commencing with *Ranunculaceæ*. The following genera and species of this order will be found in most collections. Wood anemone (*Anemone nemorosa*, L.), pilewort (*Ranunculus Ficaria*, L.), buttercup or bulbous crowfoot (*Ranunculus bulbosus*, L.), upright meadow crowfoot (*Ranunculus acris*, L.), creeping crowfoot (*Ranunculus repens*, L.), celery-leaved crowfoot (*Ranunculus sceleratus*, L.), water crowfoot (*Ranunculus aquatilis*, L.), which commonly ornaments the surface of ponds with its snow-white flowers in the spring of the year, and marsh marigold (*Caltha palustris*, L.). The following rarer and more local genera may also have been secured. Travellers' joy (*Clematis Vitalba*, L.), European globe flower (*Trollius Europæus*, L.), and green hellebore (*Helleborus viridis*, L.).

It will be easy to arrange all these genera by the help of Babington or Bentham; and the numbers will ensure to each its proper place in the collection. Even if there be only one representative species, it should be set out on a half-sheet of cartridge paper, enclosed in a

whole sheet, and the name and number of the genus written in bold characters on the outside, in the upper left-hand corner. Where there are several species of one genus, they must all be enclosed in one envelope.

All the preceding genera have the letter L. affixed to them; this means that Linnæus was the first naturalist who described them. Since the time of Linnæus, however, the number of botanists has increased, and the science of botany has advanced, so that many plants have been discovered, and added to the list of those which were known to Linnæus. Thus, in Babington's *Manual*, among the rarer or more recently discovered species *Ranunculus*, we find floating-water crowfoot (*Ranunculus fluitans*, Lam.), and *Ranunculus hirsutus*, Curt. Both of these species were unknown in the days of Linnæus; the former being first described by Lamarck, and the other by Curtius. The abbreviated forms of their names are therefore attached to the scientific names of the plants as authority for the species. The newly-discovered species of plants have become so numerous, especially in new countries, and the claims amongst botanists to priority of discovery are so conflicting, that in all cases the botanical name must be regarded as incomplete, unless it has been traced to its origin and includes that of the person by whom it was first described.

The genera, after having been thus separated, named, and numbered, should be enclosed in a stout, coloured paper wrapper, and distinguished as plants of the order *Ranunculaceæ*, or Crowfoot family, the number and name of the order being written or printed in the middle on the outside.

The orders themselves may also be arranged in extensive groups, each being characterised by some common structural peculiarity. For example, all the orders from *Ranunculaceæ* to *Rutaceæ*, which form the first sub-class THALAMIFLORÆ (Greek, *θάλαμος*, a couch), have flowers with both calyx and corolla, the latter consisting of distinct petals (polypetalous), which, together with the stamens, are inserted in the receptacle. In this, the highest group, all the parts of the flower are present and distinct from each other. The buttercup and wallflower are examples of this group. In like manner, all the

orders from *Celastraceæ*, the Spindle-tree family, to *Cornaceæ*, the Dog-wood family, are included within the second sub-class CALYCIFLORÆ (Greek, κάλυξ, a cup), having the calyx and corolla polypetalous, as in the preceding group; but these parts, as well as the stamens, are inserted in the calyx. The bramble and the rose are examples of this sub-class. The third sub-class, COROLLIFLORÆ, has the corolla gamopetalous, or the petals united, and the stamens epipetalous, or growing to the tube of the corolla. All the orders from *Caprifoliaceæ*, the Honeysuckle family, to *Plantaginaceæ*, the Plantain family, are included in this group. The primrose, cowslip, and dead nettle are examples of this group. The fourth sub-class MONOCHLAMYDÆ (Greek, μόνος, one; and χλαμύς, a coat) embraces all the orders from *Amarantaceæ*, the Amaranth family, to *Salicaceæ*, the Willow family, the flowers having no corolla, and sometimes not even a calyx. The buckwheat, oak, and willow are examples of this group.

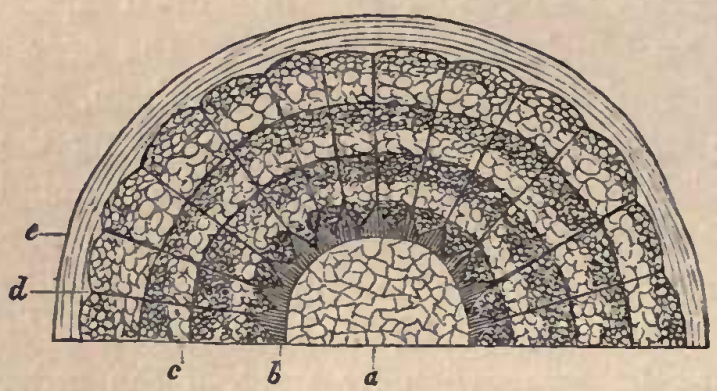
The collection of all the plants into natural orders having been accomplished, they should be divided into sub-classes, so as to reduce the number of packages and render the individual specimens more accessible. This can be done by placing the orders one upon another, as numbered in Babington or Bentham, and putting them between two stout pasteboard covers, and tying the parcel securely. The sub-class *Thalamifloræ*, and the orders should then be written or printed on a label, which should be fixed outside on the upper left-hand corner of the cover. Proceed in like manner with the *Calyciflorœ*, *Corolliflorœ*, and *Monochlamydæ*. The pasteboard covers must be proportionally stout, if the order be extensive, as in the case of *Leguminosæ*, *Rosaceæ*, or the family of the *Compositæ*.

Another plan is sometimes adopted. A box in the form of a book is made of plain deal boards, the tightly-fitting upper cover being firmly attached to one edge of the box by a strip of stout canvas, which acts as a hinge. The several orders of the sub-class are put in the box, which is closed, and placed upright on a shelf, the sub-class and orders which it contains being marked on the back. In this way the herbarium may have the appearance

of a library, and all the plants be easy of access and be protected from dust. Such botanical volumes will be of great service as works of reference, and will prove a constant source of entertainment and instruction.

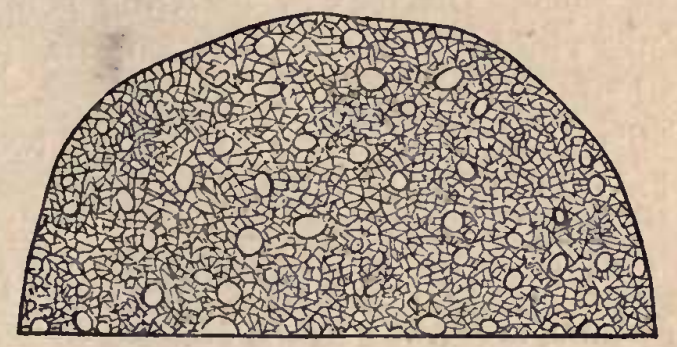
All the preceding sub-classes have a single botanical feature in common, viz., their ovules, or immature seeds are ripened in a closed vessel called an ovary; hence they are included in the first division *Angiospermia* (Greek, ἀγγεῖον, a vessel; and σπέρμα, a seed). The plants bearing seeds having an embryo with a pair of coytledons are classed in general terms as Angiospermous Dicotyledons. The other division has a polycotyledonous embryo and an open seed-vessel, fertilisation being produced by the direct action of the pollen upon the ovule; therefore it is called *Gymnospermia* (Greek, γυμνός, naked; and σπέρμα, a seed). Both these divisions are included in a still higher group.

Class I. The EXOGENS (Greek, ἔξω, without; and γεννάω, to produce) are flowering plants, producing seed, and having stems composed of bark, wood, pith, and medullary rays, the wood annually increasing externally by the addition of a new ring, and the bark internally by fresh deposits. This increase arises in both cases from the intermediate zone of vitally active cellular and fibrous sap cells called the cambium layer. The leaves are net veined, and more or less broad and dilated, or linear, awl-shaped, and scale-like. When present, the sepals and petals are in fives or fours. The cotyledons are two or more in number (*Dicotyledonous*); but *Polycotyledonous* in the *Coniferæ* only. All the plants below the Exogenous class have been included in a few comprehensive groups in the same way.



Horizontal and Vertical Section of Exogenous Stem.

Class II. ENDOGENS (Greek, ἔνδον, within, and γεννάω, to produce) are flowering plants, producing seed, having stems not separable into bark, wood, and pith, and without medullary rays. The pith or cellular tissue is spread through the interior of the stem, and the wood is distributed through it in isolated fibrous bundles, which increase in number from the centre to the circumference, in the direction of growth. The leaves are parallel-veined, and sheath the stem, but are never toothed or serrated on their margins. The parts of the flower are commonly in threes, and the embryo has only one cotyledon (monocotyledonous).



Horizontal and Vertical Section of Exogenous Stem.

Class III. ACROGENS (Greek, ἀκρός, summit; and γεννάω, to produce) are flowerless plants, producing minute bodies called spores instead of seed, in which there is no embryo, and therefore no cotyledons (acotyledonous); they have a distinct axis or stem, which grows from the apex only, and contains woody fibre and vessels. The leaves or fronds are fork-veined.

Class IV. The ANOPHYTES (Greek, ἄνω, upwards; and φυτόν, a plant) are chiefly represented by mosses and liverworts. The distinctions of root, stem, and leaves are still preserved in mosses, the stem growing upwards and the root downwards. But the structure of these plants is wholly composed of cellular tissue, and hence they are restricted to very low and humble forms, and rarely exceed a few inches in height.

Class V. THALLOPHYTES (Greek, θάλλος, a green shoot) are cellular plants consisting of simple expansions of vegetable matter, which are neither leaf nor stem, but combine the appearance and office of both. In these plants all distinction between root, stem, and leaves ceases. Lichens, fungi, and algæ constitute this last and lowest class of vegetation.

These five primary groups are finally included in the two grand sub-kingdoms of the PHANEROGAMIA (Greek, *φανερός*, apparent; and *γάμος*, marriage), or flowering plants having their stamens and pistils visible, and the CRYPTOGAMIA (Greek, *κρυπτός*, concealed; and *γάμος*, marriage), or flowerless plants, having their stamens and pistils invisible or concealed. These two sub-kingdoms include the whole vegetable kingdom.

The following is a synoptical view of the preceding arrangement of plants, according to the Natural System of Botany.

VEGETABLE KINGDOM.

SUB-KINGDOM PHANEROGAMIA—FLOWERING PLANTS.

CLASS I.—DICOTYLEDONS, OR EXOGENS.

DIVISION I.

Angiospermia—Covered Seeds.

SUB-CLASS I.—*Thalamifloræ*—Polypetalous Flowers.

Scientific Name.	Family.
I. *Ranunculaceæ*.....	Crowfoot
II. *Berberidaceæ*	Barberry
III. *Nymphæaceæ*	Water-Lily
IV. *Papaveraceæ*	Poppy
V. *Fumariaceæ*	Fumitory
VI. *Cruciferæ*.....	Mustard
VII. *Resedaceæ*	Mignonette
VIII. *Cistaceæ*	Rock-rose
IX. *Violaceæ*	Violet
X. *Droseraceæ*.....	Sundew
XI. *Polygalaceæ*	Milk-wort
XII. *Tamaricaceæ* ...	Tamarisk
XIII. *Frankeniaceæ* ...	Frankenia, or Sea-heath
XIV. *Elatinaceæ*	Water-wort
XV. *Caryophyllaceæ*...	Pink
XVI. *Malvaceæ*.....	Mallow
XVII. *Tiliaceæ*.....	Linden
XVIII. *Hypericaceæ*.....	St. John's wort
XIX. *Aceraceæ*	Maple
XX. *Geraniaceæ*	Geranium
XXI. *Linaceæ*	Flax
XXII. *Balsaminaceæ* ...	Balsam
XXIII. *Oxalidaceæ*	Wood Sorrel

SUB-CLASS II.—*Calycifloræ*—Polypetalous Flowers.

Scientific Name.	Family.
XXIV. *Celastraceæ*.....	Spindle-tree
XXV. *Rhamnaceæ* ...	Buckthorn
XXVI. *Leguminosæ* ...	Pea
XXVII. *Rosaceæ*	Rose
XXVIII. *Lythraceæ*	Loosestrife
XXIX. *Ceratophyllaceæ*	Hornwort
XXX. *Onagraceæ*	Evening Primrose
XXXI. *Halorageaceæ* ..	Water-Milfoil
XXXII. *Cucurbitaceæ*...	Gourd
XXXIII. *Portulacaceæ*...	Purslane
XXXIV. *Paronychiaceæ*	Whitlow-wort
XXXV. *Crassulaceæ* ...	Stone-crop
XXXVI. *Grossulariaceæ*	Currant
XXXVII. *Saxifragaceæ*	Saxifrage
XXXVIII. *Umbelliferæ* ...	Parsley
XXXIX. *Araliaceæ*	Ivy
XL. *Cornaceæ*	Dogwood

SUB-CLASS III.—*Corolliflorœ*—Gamopetalous Flowers.

Scientific Name.	Family.	Scientific Name.	Family.
XLI. *Loranthaceæ* ...	Mistletoe	LIII. *Polemoniaceæ*...	Polemonium
XLII. *Caprifoliaceæ* ...	Honeysuckle	LIV. *Convolvulaceæ*	Convolvulus
XLIII. *Rubiaceæ*.....	Madden	LV. *Boraginaceæ* ...	Borage
XLIV. *Valerianaceæ* ...	Valerian	LVI. *Solanaceæ*	Nightshade
XLV. *Dipsacaceæ*	Teasel	LVII. *Orobanchaceæ*...	Broom-rape
XLVI. *Compositæ*	Composite	LVIII. *Scrophulariaceæ*	Figwort
XLVII. *Campanulaceæ*	Campanula	LIX. *Labiatæ*	Mint
XLVIII. *Ericaceæ*.....	Heath	LX. *Verbenaceæ*.....	Vervain
XLIX. *Ilicineæ*	Holly	LXI. *Lentibulariaceæ*	Bladderwort
L. *Jasminaceæ*.....	Jasmine	LXII. *Primulaceæ* ...	Primrose
LI. *Apocynaceæ*.....	Dogs-bane	LXIII. *Plumbaginaceæ*	Leadwort
LII. *Gentianaceæ* ...	Gentian	LXIV. *Plantaginaceæ*	Plantain

SUB-CLASS IV.—*Monochlamydeæ.*—Apetalous Flowers.

Scientific Name.	Family.	Scientific Name.	Family.
LXV. *Amaranthaceæ*	Amaranth	LXXI. *Aristolochiaceæ*	Birthwort
LXVI. *Chenopodiaceæ*	Goosefoot	LXXII. *Empetraceæ* ...	Crowberry
LXVII. *Polygonaceæ* ...	Buckwheat	LXXIII. *Euphorbiaceæ*...	Spurge
LXVIII. *Elæagnaceæ* ...	Oleaster	LXXIV. *Urticaceæ*.....	Nettle
LXIX. *Thymelæaceæ* ...	Mezereum	LXXV. *Amentaceæ*	Amentiferous
LXX. *Santalaceæ*	Sandal Wood		

DIVISION II.

Gymnospermia—Naked Seeds.

LXXVI. *Coniferæ* Pine Family.

CLASS II.—MONOCOTYLEDONS, OR ENDOGENS.

SUB-CLASS I.—*Spadiciflorœ.*

Flowers on a Spadix, either naked or enclosed in a Spathe.

Scientific Name.	Family.	Scientific Name.	Family.
LXXVII. *Araceæ*	Arum	LXXIX. *Typhaceæ* ...	Cat-tail
LXXVIII. *Lemnaceæ* ...	Duckweed	LXXX. *Naiadaceæ*...	Pondweed

SUB-CLASS II.—*Petaloideæ.*

Having floral envelopes arranged in whorls.

Scientific Name.	Family.	Scientific Name.	Family.
LXXXI. *Alismaceæ* ...	Water-plantain	LXXXVII. *Asparageæ* ..	Asparagus
LXXXII. *Hydrocharidaceæ*	Frog's-bit	LXXXVIII. *Liliaceæ*	Lily
LXXXIII. *Orchidaceæ* ...	Orchis	LXXXIX. *Colchicaceæ*	Colchicum
LXXXIV. *Iridaceæ*	Iris	XC. *Juncaceæ* ...	Rush
LXXXV. *Amaryllidaceæ*	Amaryllis	XCI. *Restiaceæ* ...	Pipewort
LXXXVI. *Tameaceæ*.....	Black Bryony		

SUB-CLASS III.—*Glumaceæ.*

Floral envelopes, consisting of Glumes or Scales.

Scientific Name.	Family.	Scientific Name.	Family.
XCII. *Cyperaceæ*	Sedge	XCIII. *Gramineæ*	Grass

SUB-KINGDOM CRYPTOGAMIA—FLOWERLESS PLANTS.

DIVISION III.

Angiospora—Spores in a Vessel.

CLASS III.—ACOTYLEDONS, OR ACROGENS.

Natural Orders.

1. *Equisetaceæ*, Horsetails. 2. *Filices*, Ferns. 3. *Hydropterides*, Water Ferns. 4. *Lycopodiaceæ*, or Club Mosses.

CLASS IV.—ANOPHYTES.

1. Mosses. 2. Liverworts. 3. Stoneworts.

DIVISION IV.

Gymnospora—Spores Naked.

CLASS V.—THALLOPHYTES.

1. *Lichens.* 2. *Algæ*, or Sea-weed. 3. *Fungi*, or Mushrooms.

From the preceding Synopsis it is evident that the flowering plants are by far the most numerous. To many persons they are also the most interesting. They are interesting on account of their wide differences of form, and colour, and habit, and on account of the similarities between different members of the same family. An observant student will note how an acquaintance with the essential features of one member of a family will lead to easy recognition of the same features in another member. An intimate knowledge, for instance, of the botanical peculiarities of the common marsh-mallow will serve for the 700 species which the Malvaceæ include. He sees that it is characterised by a slimy secretion, and a fibrous tissue, tough and woody, capable of being made into cordage: wherever in the world he wanders, if he finds a member of the mallow family, he will find its slimy secretion and tough fibre; and there, if need be, he can twist a stout cord that will serve to bind his other specimens together. It is by this acquaintance with family characteristics that we find out how the plants of one country are substitutes for the useful plants of another country.

But these and other interesting facts must be learned from a study of plants under the direction of a good book on botany. Many such are published; and to these we must refer our young readers; for within the space we can give to the matter in this volume it is quite impossible to describe in detail all the flowering plants of our native land. We advise them to begin with a small volume, and to study thoroughly a few plants, and then, under the guidance of a larger volume, to study more thoroughly a larger number of plants. We hope they will not be discouraged because there is so much to learn, but begin with being thorough in their acquaintance with a few plants, and thence be encouraged to advance in knowledge. Thus only can the wide field of nature be won as an imperishable possession; thus only can we satisfactorily study the beauty and utility of His works, who in the infinity of thought and handiwork is really "past finding out."

As the flowerless plants are fewer in number, and an account of them may be less easily accessible, and we can compress some information respecting them into a small space, we now proceed to describe them.

The Cryptogamous, or Flowerless Plants.

These are plants destitute of proper flowers, or without stamens and pistils; they have, nevertheless, reproductive organs, antheridia and pistillidia, which co-operate in the production of minute bodies called spores, from which new plants are developed.

Every plant germinating from the seed or spore has a tendency to develop upwards, downwards, or horizontally, according to the nature of the tissues of which it is composed. The fibrous and vascular system is developed vertically, and the cellular horizontally. The former enters into the structure of the higher tribes of cryptogamic plants, which therefore form an elevated trunk or stem, increasing in altitude by additions of cellular and vascular tissue at its extremities, but without growing in diameter. Hence this class of Cryptogams are called Acrogens (Greek *ἀκρός*, summit, and *γεννάω*, to produce), or summit-growers. It includes the following natural orders:

I. The Higher Cryptogams (*Vasculares*).

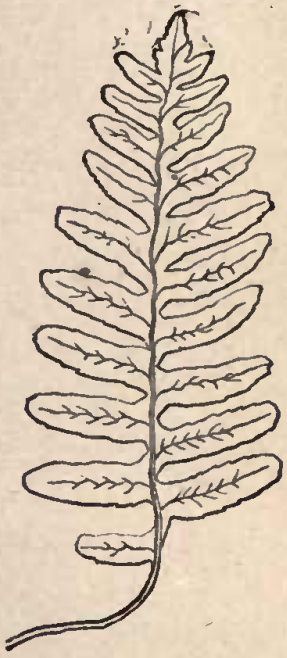


Fertile Spring Frond and Barren Summer Frond of Common Horse-tail.

1. The *Equisetaceæ*, or horse-tail family, is represented by the common horse-tail (*Equisetum arvense*, L.). The stems of these plants are simple or branched, striated longitudinally, tubular, and articulated, the cavity of the stem being closed at the articulations, which are surrounded by a membranous toothed sheath, and are readily separable. The whorls of branches in the barren summer frond are jointed, striated, and tubular, and solid and sheathed at the joints, like the stem from which they spring. The fertile spring frond is devoid of branches, and bears at its summit the organs of fructification, an ovate cone or spike, more or less elongated, composed of shield-shaped, stalked, polygonal scales, bearing the spore cases (sporangia) underneath. Attached to the base of each spore are four-thread-like, club-shaped elastic filaments, which coil closely around the spore when moist, but uncoil when dry, and thus move the spore along with them. If a spike of the Equisetum be shaken over white paper when it is ripe, in the month of April, the spores will drop like brown powder on its surface; and if these are breathed upon and examined with

a microscope, they will be seen crawling about like so many spiders. This arises from the absorbent property of the elaters affixed to the spores, and is the means of effecting their dispersion. These plants grow in moist situations, and have stems about half an inch in diameter, with a height varying from two feet to even twelve feet in tropical marshes. Both the fertile and the barren fronds must be gathered to make the specimens complete.

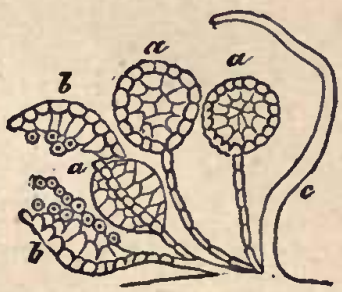
2. The *Filices*, or Ferns, are illustrated by the common polypody (*Polypodium vulgare*, L.). The name frond (*frons*, a bough) is given to the leafy appendages of the stems of ferns, because they are more analogous to flattened branches than to proper leaves; an example of this is the butcher's broom (*Ruscus aculeatus*, L.). In early spring the fronds of ferns are in bud and circinate, or rolled up from apex to base in a beautiful spiral. The adder's tongue (*Ophioglossum vulgatum*), a somewhat rare English fern, is an exception to this rule, as its fronds are straight even from the beginning of their development. The unrolled fronds are plentifully covered with membranous, chaffy scales; but as the heat of the sun increases these fall off, and the fronds gradually unroll until their surface is entirely spread out. When the frond is fully grown, the thecæ, or spore-cases,



Upper Surface of Frond of Common Polypody.



Under Surface of Frond of Common Polypody, with clusters of thecæ or spores.



Portion of a sorus of Common Polypody (highly magnified).

appear on its under surface in clusters; they are scientifically termed sori (Greek, σωρός, a heap), appearing to the naked eye like circular or oblong heaps of powder. The woodcut represents a cluster of thecæ, surrounded by an elastic ring of cells, called the annulus, *a*, *a*, *a*; when the thecæ become dry, and the spores are matured, the rings straighten, opening the spore-case, and scattering the seed, *b*, *b*.

In the case of the common polypody the thecæ are generally formed above the cuticle; but usually they are at first concealed under the cuticle, which they raise up like a blister, and ultimately rupture and detach from the frond in a variety of ways. This ruptured cuticle is termed the indusium, and can only be detected in the early spring, as later on it withers away, leaving exposed the clusters or sori. Sometimes the indusium is a mere fold of the margin of the frond, as in the common brake (*Pteris aquilina*) and maiden-hair (*Adiantum*). In the tropics, and particularly in Australia, ferns grow into lofty trees, with trunks from fifty to sixty feet in height, crowned at their summits by magnificent heads of gigantic fronds, which hang gracefully or wave majestically in the brilliant sunshine. These fronds are sometimes several yards in length, and are finely divided. As the lower fronds decay and fall from these tree ferns, the upper fronds gradually unroll and become pendent, and thus the bases of the fallen fronds form a light stem or trunk, the growing point being continually carried upwards.

3. The *Lycopodiaceæ*, or club-mosses, are represented by the genus Lycopodium. This little family appears to occupy a position between the ferns and mosses, and in some respects seems to be allied to the Coniferæ, or pine family. They are moss like plants, and have roots of a secondary character, that is, roots not confined to one extremity of the stem, but springing from all parts of it in contact with the earth. The numerous evergreen leaves are subulate, or awl-shaped, and have an epidermis pierced with true stomata, or breathing-spores, spirally disposed about the branches of the somewhat bifurcating stem. The reproductive capsules are situated in the axils of the terminal metamorphosed leaves of the stem, which form

iong, yellow, clavate spikes; these ripen in summer, when they shed abundantly the golden yellow spores, or "Lycopodium powder."

These plants, of which the club-moss *(Lycopodium clavatum)* is the type, are common on heaths and moors in hilly districts; they are especially interesting as being the most nearly allied to the fossil Lepidodendrons (Greek λεπίς, a scale, and δένδρον, a tree) of now existing plants. These scaly trees grew during the carboniferous period, or the epoch when the coal was deposited. They were similar in structure to the Lycopodiums, being in fact gigantic club mosses.

The other vascular Cryptogams, the Filices and Equisetaceæ, also have their representatives in the earth's ancient flora. Fossil Equisetaceæ abound in the coal measures, and in strata of more ancient date. Some of them attained an enormous size, having a height of from thirty to forty feet, with a diameter of from one to three feet. In most instances, the stems of these plants are found pressed flat, but specimens have been met within a vertical position, which retained their cylindrical character.



Club Moss, with Fruiting Spikes.

Fossil ferns seldom exhibit any traces of fructification, and are chiefly distinguished by their shape and the forked veins of their fronds. About one hundred and fifty species of fossil ferns have been discovered in the coal strata of England. The originals of many of these species undoubtedly grew as trees. Fossil fern stems are rarely found, yet a few have been dug out bearing conspicuous cicatrices or scars, similar to those left by the fallen fronds on the stems of living tropical tree ferns. These scars give an accurate and valuable indication of their true character.

II. The Lower Cryptogams (*Cellulares*).

Mosses.

Few common objects are more interesting than *Musci*, or Mosses, which require neither skill nor instruments for the detection of their beauties. Mosses are composed solely of cellular tissue, and have a distinct stem or axis of growth, around which the minute leaves are arranged with great regularity. The leaves assume a regular specific form, with entire, serrate, or denticulate margins; they have a sort of midrib or nerve in the centre formed of condensed cells. Sometimes, however, the leaves are nerveless, as in



Different Species of Feather Moss.

the case of *Hypnum purum*, a common British species. Sometimes the stem is procumbent, or rests upon the ground, the branches are forked and spread out, emitting rootlets from every part of their under surface, and the capsules or fruit come out from

the sides of the branches. In other species, the stem takes an ascending direction, the rootlets are confined to one end of the stem, and the fruit is borne at the summit of the branches. The mosses bearing lateral fruit, such as *Hypnum*, are called Pleurocarpi (Greek, πλευρά, the side, and καρπός, fruit); those in which the fruit is terminal, for instance, Catharinea, are called Acrocarpi (Greek, ἀκρός, summit, and καρπός, fruit).

Careful examination of a fertile moss will show a number of urn-shaped bodies arising from the midst of the foliage; these are called sporangia (Greek, σπορά, a spore, and ἀγγεῖον, a vessel), or spore vessels. These sporangia are at first covered by a membrane called a calyptra, or veil (Greek, καλύπτρα, a covering). This is shown in the engraving of the *Catharinea undulata*. When the calyptra has fallen, the sporangium is seen to be covered by an operculum, or lid, represented in the wood-cut as visible through the calyptra; this assumes different shapes in different species, being convex in rose-star moss (*Mnium roseum*), conical in hair moss (*Polytrichum*), and rostrate (Latin, *rostrum*, a beak) in broom moss (*Dicranum scoparium*). As fructification advances, the operculum or lid falls, and the peristome (Greek, περί, around, and στόμα, a mouth), or mouth of the spore vessel, is revealed, which in some species presents the appearance of a beautiful fringe; but this organ can only be distinguished by a microscope. On examination there will be found an outer and an inner peristome, the former usually exhibiting a number of broad, lance-shaped processes called teeth, and the latter a fringe of long, filamentous cilia (Latin, *cilium*, an eyelash). The teeth of mosses form beautiful microscopic objects, and will be found to follow a regular numerical law, being either 0, 4, 8, 16, 32, or 64, with no intermediate numbers. The generic character of mosses is determined not only by the presence or absence of these teeth, but by their number, degree of cohesion, and



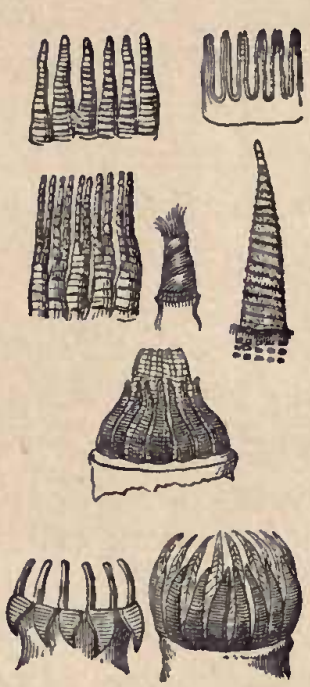
Sporangia of *Catharinea undulata.*



Sporangia of Rose-star Moss.



Sporangia of Broom Moss.



Different forms of Peristome.

colour. The peristome varies in form and colour in almost every kind of moss. Several mosses derive their names from the colour of the peristome, as purple-toothed moss (*Didymodon purpureum*), which is very common, and white-toothed moss (*Leucodon*); or the teeth may be long and twisted, as in *Tortula*, or short and twisted, as in beard moss (*Barbula*), or forked, as in *Dicranum*, or split-toothed, as in *Fissidens;* or the peristome may be naked and devoid of teeth, as in *Gymnostomum.* Most systems of mosses are based on the structure of the peristome, which must be studied with the aid of the microscope to determine the genera.

The teeth of mosses are very sensitive to moisture, spreading outwardly at right angles to the mouth of the sporangium in fine



Fissidens.





Barbula Moss.

weather, when the sunshine is brilliant and the air dry; but curving inwardly and closing the aperture in dull, damp weather. This peculiarity may be seen in operation even with a small pocket lens in *Barbula* moss, which will be found growing on the top of almost every old stone and brick wall during the winter months either in town or country.

The sporules or reproductive germs of mosses are contained in sporangia, and are generally attached to a central axis, called a

columella, or little pillar, which is a continuation of the stalk or support of the spore vessel into its cavity. The sporules when ripe escape through the mouth of the sporangium into the atmosphere. These sporules are very minute and buoyant, so it is not surprising to find mosses growing in crevices of almost inaccessible cliffs, and specimens of one species thousands of miles apart.



Apple Moss.



Tree Moss.

The following mosses will be easily identified: The apple moss (*Bartramia pomiformis*) grows in beautiful green tufts in rocky woods, and is readily recognised by its globular sporangia, as also the pear moss (*Bryum pyriforme*) will be by its pear-formed spore vessels. The tree moss (*Climacium dendroides*) may be readily known by its prostrate stems and bushy upright branches. The cushion moss (*Grimmia pulvinata*), a common moss on stone walls enclosing woods or plantations, is identified by its oval cushion-like tufts, numerous egg-shaped sporangia, and short golden yellow stems. The straight-hair moss (*Orthotrichum*) will be found on the bark of trees, with double peristome and teeth at right angles to its open operculum. The cord moss (*Funaria hygrometrica*), with twisted, cord-like fruit-stalks, and grapestone-like sporangia far overhanging the stalks, is worth knowing. The fruit stems of this moss twist in dry weather, and untwist when the air is moist. It usually grows where there has been a fire. Several species of bog moss (*Sphagnum*) grow in the bogs around London. The *Sphagnum obtusifolium* is a large species easily distinguished from the



Cushion Moss.



Straight-hair Moss.



Bog Moss.



Cord Moss.

others by its swollen blunt bunches growing in little bundles or branches from the stem, and by its closely-imbricated leaves. The *Sphagnum acutifolium* is generally found growing in the same bog with the foregoing, and may be known by its fascicles (Latin, *fasciculus*, a little bundle) of more slender drooping branches. The genus Sphagnum has no calyptra. The colour of the foliage is pale green, which dries to a pearly whiteness. The leaves are beautiful objects for the microscope; they are without a costa, or midrib, and the cells of which they are composed contain spiral fibre. These water plants are very widely diffused over the surface of the earth, hardly any limits to their geographical distribution being known.

Speaking of the Sphagnum, Linnæus says, in his *Flora Lapponica:* "The Lapland matrons are well acquainted with this moss. They dry and lay it in their children's cradles, to supply the place of bed, bolster, and every covering; and being changed night and morning, it keeps the infant remarkably clean, dry, and warm. It is sufficiently soft of itself; but the tender mother, not satisfied with this, frequently covers the moss with the downy hairs of the reindeer, and by that means makes a most delicate nest for the new-born babe."

The bog moss is also remarkable for the part which it takes in the formation of peat, the lower portions of the stems continually dying away, while the summit continues to grow upon the surface. The peat bogs are often of great depth, some of them having increased as much as eight feet since the Romans occupied our country. The value of peat as material for fuel is well known in countries where wood is scarce.

One of the most common and extensive of the genera of mosses is the *Hypnum*, or feather moss. Müller, in his synopsis, has enumerated no fewer than five hundred species, many of them common to both Europe and America. Eighty-six species are described in the *Botany of the Northern United States.* These mosses are very common, and easily recognised by their trailing habits. They cover the ground in extensive mats, developing their numerous sporangia from the axils of their stems. The calyptra is smooth, and the peristome double.

The most beautiful species is the ostrich-feather moss (*Hypnum*

crista-castrensis), which grows abundantly, along with the *Hypnum splendens*, in the Alleghany mountains. The *Hypnum proliferum* is very abundant in the woods about Philadelphia, and may be readily distinguished by its tripinnate stems and opaque yellowish green foliage. The *Hypnum rutabulum* is the beautiful velvet-like moss so common on the ground. The stalks of its sporangia are very rough. The *Hypnum Schreberi* is easily recognised by its pale yellowish green foliage and bright red stems. All these species are abundant with us, and cannot fail to attract attention on a bright winter's day if the ground should be free from snow.

The largest variety of the British mosses is the common hair-moss (*Polytrichum commune*), which has an extensive geographical distribution. It varies in size from a few inches to a foot in length, and grows in large tufts or cushions, which are not unlike a miniature plantation of fir-trees. The *Polytrichum commune* has an erect simple stem, with linear awl-shaped recurved spreading leaves, notched on the margins and on the back of the midrib. It fructifies in summer. The word Polytrichum means literally "many-haired," and has reference to the dense hairy calyptra which surmounts the oblong four-sided sporangium. This moss increases in size and abundance as we go farther north. It is used by the Laplanders for bed and bedding, like the *Sphagnum*, as in the quotation given above from Linnæus, who, moreover, in his wanderings in search of botanical rarities in that inhospitable clime, often made his bed on the close and matted stems of the Polytrichum.

The silver moss (*Bryum argenteum*) has been called by Dillenius the "catkin-stemmed silver moss." It grows on wall-tops, old thatched roofs, by the roadsides almost everywhere, in deep silvery green tufts; its compact stems, formed by the closely-adpressed leaves, resemble silvery miniature catkins. like those of the birch and alder. It is so different from any other moss around, and so common, that the reader cannot fail to find it, taking the above description as a guide. In warm climates the leaves are tipped with long hairs, so that it looks like tufts of wool, whence the name of the variety, woolly bryum (*Bryum lanatum*).

The tufted bryum (*Bryum cæspiticium*) is one of the first mosses

the beginner is likely to find. It grows everywhere in Europe and America, and may be readily known by its green, drooping egg-shaped sporangia, which remain in an immature state through winter and ripen in early spring.

All the mosses have been figured and described by Dr. Hooker, and may be easily studied by the aid of a microscope sufficiently powerful to give a clear and well-defined view of the peristome, with its teeth and cilia, and show the leaves with their nervures, serratures, denticulations, and other specific peculiarities.

Liverworts.

The *Liverworts* (*Hepaticæ*) are green plants found amongst moss, upon the bark of trees, and on the ground, which occupy positions between mosses and lichens, and are readily distinguished from mosses by their frondose, or scaly appearance.

The lower forms of the Hepaticæ are somewhat lichenose in their aspect; they are lobed and continuous masses of green vegetable matter lying on the ground, emitting root-hairs from every part of their under surface, as in brook liverwort (*Marchantia polymorpha*). The higher Hepaticæ are more leafy, although the organisation of the minute scale-like leaves is of the simplest character. They resemble, in some species, a series of imbricated scales, with others in an imperfect state (*amphigastria*) on the under side. Above this simple vegetation rise numerous capillary stalks, bearing on their summits brown valvular cases containing the spores, often mixed with spiral filaments called elaters. These sporangia are without calyptra, operculum, or peristome, and in most genera without a columella, opening at the apex by four spreading valves.

It is extremely difficult to collect Hepaticæ in fruit, unless it be some of the most common species, for the stalk which supports the sporangium usually consists of a mass of loose, elongated, cellular tissue; this is greenish, or, when fully developed, of transparent whiteness. By the appearance of these organs of reproduction, we are reminded of the delicate stalks of the minute fungi or moulds. They fly away very quickly, hence the collector

not unfrequently has the misfortune to meet with the fruiting foliage of interesting species covered with the remains of sporangia and footstalks, which, if collected a few hours sooner, would have afforded him elegant objects for his herbarium. The severest frost does not injure the delicate foliage or fruit of these hardy minute plants. All the British genera of Hepaticæ are admirably figured and described in Hooker and Taylor's *British Jungermannia.*

The *Characeæ*, *Charæ*, or stoneworts, are a singular group of plants growing in pools and sluggish streams. They give out a very offensive odour, which is supposed by some persons to produce a pestilential disease, when the plants grow in large numbers, as in the neighbourhood of Rome. These plants are leafless, their stems are jointed, and at the joints, growing round them in whorls or rings, are small branches. These are composed of one or several tubes bound together in bundles, transparent or encrusted with chalky matter; hence their name, stonewort. The reproductive organs are of two kinds. The Characeæ are highly interesting to those who possess a microscope, because with this instrument the circulation of the nutritive fluid can be seen with the aid of transmitted light. So long as the plant is alive, the circulation up one side and down the other side of the tubular stem is distinctly seen. The species are met with all over the world, but are most abundant in temperate climates.

Lichens.

Lichens are perennial plants which belong to the lowest type of vegetation, having neither root, stem, nor leaves, all of which parts are well-defined and distinctly visible in mosses. The vegetative functions of absorption, circulation, and assimilation are carried on by lichens without these organs, which are, as it were, blended together in these plants into a much simpler form of structure, called a *thallus*, or sprout. The thalli of lichens are usually horizontal expansions of vegetable matter, pulverulent, scaly, foliaceous (or leaf-like), or even, as in the higher forms, fruticulose, or shrubby in appearance. The lower types of lichens are common on old walls, fence-rails, house-tops, the bark of trees, and the surface of rocks, and the higher or shrubby forms on the ground,

especially on heaths and moors where the country is elevated, or in Alpine regions. The colour of lichens is very rarely green—the prevailing colours are white and grey; yellow, orange, brown, and black are somewhat rarer.

The pulverulent and crustaceous lichens are decidedly the lowest in organisation. They are variously coloured—white, yellow, and green, the different lines marking the boundaries of the several thalli of the species being well-defined. The smooth bark of any old beech-tree will enable the reader to verify this fact. The poet Crabbe has well described this lowest class of lichens in the following lines:

> "The living stains which Nature's hand alone,
> Profuse of life, pours forth upon the stone;
> For ever growing, where the common eye
> Can but the bare and barren rock descry.
> There Science loves to trace her tribes minute—
> The juiceless foliage and the tasteless fruit;
> There she perceives them round the surface creep,
> And, while they meet, their due distinctions keep,
> Mixed, but not blended, each its name retains,—
> And these are Nature's ever-during stains."

The letter lichen (*Graphis scripta*) is common on the bark of beech-trees. In this instance there is some resemblance to Hebrew character. In other species the lichen takes the form of stellate or serpentine lines, or even of commas, semicolons, notes of interrogation, or of illegible scribble.



Letter Lichen.

The geographical lichen (*Lecidea geographica*) is another interesting crustaceous lichen growing on rocks near the snow-line. In the yellow crust of this lichen Nature has drawn black lines, resembling islands and continents, hence its popular name.

The foliaceous and shrubby forms of these plants belong to the higher type of lichenose vegetation. As an example of the former we select the common wall-lichen (*Parmelia parietina*), which grows in abundance on old stone walls and on the tiled roofs of out-houses in the farmer's yard. This plant is a circular expansion

of bright, orange-coloured vegetation, somewhat scaly in its aspect, divided into segments at its margin called laciniæ or lobes, according to their breadth or narrowness; it is covered with circular shields or saucer-like discs, which contain the spores or reproductive matter. Hence its generic name, *Parmelia* (Greek, πάρμη, a shield, and εἰλέω, to enclose), and its specific name *parietina* (Latin, *paries*, a wall), in allusion to its habitat.



Wall Lichen.

The stone-lichen (*Parmelia saxatilis*) is a very common, grey, smooth, leafy, shield lichen, with the dark chestnut shields or cups visible on its upper surface. Where this lichen grows there are generally several of them in different stages of growth; and the reader can thus compare them, and easily convince himself of their low degree of vitality, slow growth, and increase at the circumference. Lichens are the slowest growing of all plants; we have, in fact, no data by which their age can be determined.



Stone Lichen.

As an instance of the shrubby lichen, we must refer the reader to the reindeer moss (*Cladonia rangiferina*), which grows abundantly along with the fern among the heather in the hilly and mountainous tracts of the United Kingdom. This is in reality not a moss, but a shrubby lichen, a few inches in height, of a white colour, and resembles a miniature tree deprived of its leaves. In the Arctic regions this lichen forms the



Reindeer Lichen.

sole subsistence of the reindeer during winter. It is, of course, buried beneath the snow, which the animal removes with his large branching horns. It is a remarkable fact that the reindeer, when feeding on this lichen, fattens better, has a cleaner skin, and finer hair than in summer, when feeding on the best herbage.

In the leafy thallus the reproductive matter is either contained in circular shields called apothecia (Greek, *ἀποθήκη*, a repository), or it bursts through the surface or margin of the thallus in mealy mosses termed soredia (Greek, *σωρός*, a heap). But the shrubby thallus bears its fructification at the extremities of its numerous branches, as in the reindeer-lichen. In the cup-lichens the ends of the branches are dilated into funnel-shaped cavities. The fructification is situated on the margin of these cavities, and is of a brown or scarlet colour. The main body of the thallus, from whence the ramifications take their rise, is called the podetium (Greek, *πούς*, a foot); sometimes the branches are suppressed, and the podetium



Cup Lichens.

itself is dilated at its apex into little cups, which bear on their margin the fuscous or scarlet apothecia, as in the cup-lichen (*Cladonia pyridata*). Fruticulose lichens with scarlet apothecia may be found on the decaying stumps of old trees, and are deservedly admired.

The filamentous thallus is represented by the beard-moss (*Usnea*), whose grey tufts may be seen clothing stems and hanging from the branches of old trees, especially in winter, when deprived of their leaves. The thallus in this instance is divided into long, thread-like, rounded, and attenuated segments, having a cartilaginous or leathery cortical layer, which is very apt to crack on its surface

into annuli or rings, disclosing the white cottony medullary tissue beneath. The sporules are contained in circular shields at the extremities of the branches.



Beard Lichen.

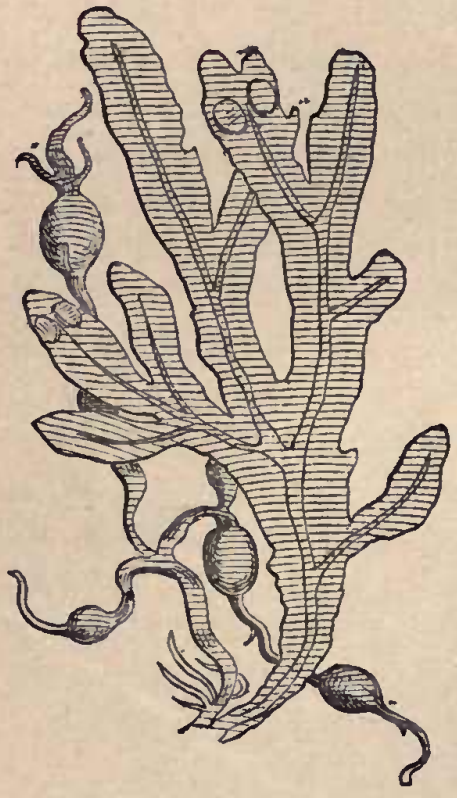
The lichens of the United Kingdom have been figured and described by Sowerby. Loudon's *Encyclopædia of Plants* may also be consulted with profit.

The following passage from Ruskin's *British Painters* is not only beautiful, but true, and is, therefore, appended to this brief sketch of the natural history of these plants: "Lichens and mosses—how of these? Meek creatures! the first mercy of the earth, veiling with hushed softness its dintless rocks; creatures full of pity, covering with strange and tender honour the scarred disgrace of ruin—laying quiet finger on the trembling stones to teach them rest. No words that I know of will say what these mosses are. None are delicate enough, none perfect enough, none rich enough. How is one to tell of the rounded bosses of furred and beaming green, the starred divisions of rubied bloom, fine filmed, as if the rock spirits could spin porphyry as we do glass, the traceries of intricate silver and fringes of amber, lustrous, arborescent, burnished through every fibre into fitful brightness, and glossy traverses of silken change, yet all subdued and pensive, and framed for simplest, sweetest offices of grace. They will not be gathered like the flowers for chaplet or love-token, but of these the wild bird will make its nest, and the wearied child his pillow. And as the earth's first mercy, so they are its last gift to us. When all other service is vain from plant and tree, the soft mosses and grey lichens take up their watch by the head-stone. The woods, the blossoms, the gift-bearing grasses have done their parts for a time, but these do service for ever. Trees for the builder's yard, flowers for the bride's chamber, moss for the grave. Yet as in one sense the humblest, in another they are the most honoured of earth's children. Unfading as motionless, the worm frets them not, and the autumn wastes not. Strong in loneliness, they neither blanch in heat nor pine in frost. To them, slow-fingered, constant-hearted,

is entrusted the weaving of the dark eternal tapestries of the hills; to them, slow pencilled, iris-dyed, the tender framing of their endless imagery. Sharing the stillness of the unimpassioned rock, they share also its endurance; and while the winds of departing spring scatter the white hawthorn blossom like drifted snow, and summer dims on the parched meadow the drooping of the cowslip gold, far above among the mountains the silver lichen-spots rest, star-like, on the stone, and the gathering orange-stain upon the edge of yonder peak reflects the sunsets of a thousand years."

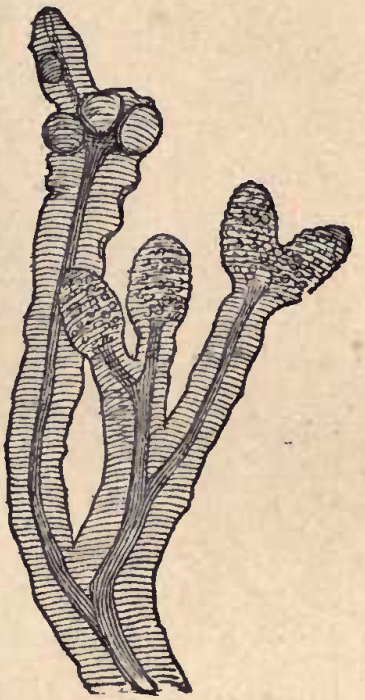
Algæ.

The *Algæ* include seaweeds, lavers, and the floating scum-like substances which grow under water in damp places, ditches, and rivers. Some are of the most simple structure, consisting of mere microscopic vesicles; others are compound woody plants, with branches extending to an enormous length. Some are visible to the naked eye only when they occur in clusters and heaps; others form floating obstructions to the course of ships. The three subclasses into which they have been divided are termed Melanospermeæ, Rhodospermeæ, and Chlorospermeæ. The *Melanospermeæ* are all sea plants, olive-green or olive-brown in colour, with olive-coloured spores, each enclosed in a transparent covering, and either simple or separating into two, four, or eight sporules. The order Fucaceæ is well-known on our coasts, particularly the *Fucus vesiculosus*. Their long, leathery stems, at the end of which there is a hard shield-like root, have been torn from the rocks on which they grew by the violence of the waves, and thrown upon the shore. The *F. vesiculosus* is characterised by its olive-green straps, forked at the end with little yellowish, oval, uneven pods at the points, and by the crackling



Fucus vesiculosus.

caused by the rupture of the little air bladders when they are crushed. The pods contain a number of round balls in which is a jelly-like substance, enclosing numerous small oval spores connected by jointed threads. Kelp used to be made from this *Fucus*, but the manufacture has greatly declined since other manures have been introduced. Another order, the Laminariaceæ, includes the *Laminaria digitata*, which is eaten as tangle by the Scotch. The midrib of the *L. esculenta* is also eaten; so is the *L. saccharina*, both in Iceland and Japan. These sea-weeds also make excellent manure.



Laminaria digitata.

The *Rhodospermeæ* are very nearly all sea plants, and generally of a brilliant rose-red or purple colour. Their fronds are leaf-like, and their spores are either collected in clusters, or, if scattered, are arranged in masses of the frond on a ternary plan. The *Chondrus crispus* or Carrageen moss, belongs to this sub-class. It is used extensively in Ireland as an article of food, and in other parts of the kingdom as a substitute for Iceland moss, or for isinglass in the preparation of blanc-mange and jellies. The *Gelidium* is the sea-weed used by swallows in the construction of the edible nests of Java, which are regarded by the Chinese as a great delicacy. The *Halymenia palmata* is of considerable value to the Icelanders, who wash it, dry it, and then pack it in casks to be preserved for use. The white powder which it contains is sugary and palatable; hence it makes a pleasant addition to the tables of both rich and poor. Cattle and sheep are also very fond of it. Among the Rhodospermeæ are also included the Gracillaria, several species of which are used as food. *G. tenax* is used by the Chinese in the preparation of glue and varnish, also to strengthen the paper of lanterns, and to give a gloss to silk or gauze.

The *Chlorospermeæ* are green sea or fresh water plants, propagated by green spores dispersed through all parts of the frond. The Confervæ, which belong to this sub-class, are found wherever there

is water, in stagnant pools and ponds, on stones at the bottom of running water, on the sides of springs, often growing with very great rapidity, and covering lakes and streams to a very wide extent. The Porphyra, or purple lava, has a plain, purple, exceedingly thin frond; grows on rocks and stones, and is thrown up all round our coasts from spring to autumn, where it is gathered for the sake of its nutritious gelatinous matter. It is reproduced by roundish granules arranged in fours in the substance of the frond, and by smaller egg-shaped granules lying without order near its margin. The *Ulva lactuca*, or lettuce green lava, known as oyster green, and *U. latissima*, the broad green lava, with a plain, roundish, waved, green and delicate frond, are gathered and eaten in the same way as the purple lava. The different species of Oscillatoria are found abundantly in fresh water, some in tepid springs, others in damp places. The *Protococcus nivalis*, belonging to the order Palmellaceæ, has been supposed to be the cause of red snow in high latitudes. The *Palmella cruenta* is of a dark red colour, and growing on white-washed walls, especially in damp cellars, has sometimes occasioned alarm on account of its having the appearance of stains of blood. These are among the lowest forms of Algæ. But, however low their forms, however simple their structure, and however limited and inferior their life, they have never been constructed by human hand, but testify "the Hand that made us is Divine."

Fungi.

The *Fungi* include not only toadstools and mushrooms, but a considerable number of those minute plants which are known as mould, mildew, smut, dry-rot, etc. They are represented on the one hand by the large fleshy boleti which grow on the trunks of trees; and on the other by the tiny filamentous mould-plants, which cannot be seen without the aid of a microscope, assuming very different forms and appearances during growth. Their shapes are very irregular; hence the same species has not unfrequently been described under different specific names. Their mode of development is concentric, and they are propagated by brown or colourless spores. The concentric growth of the spawn or stem of Fungi may

sometimes be observed in damp, dark cellars, where they can grow freely on decaying wood; the white flocculent matter, thallus, or spawn, which a gust of air will almost blow away, radiating from a centre in all directions. This is the first development from a spore, constituting the stalk, on which, under the influence of a small amount of light, grows the spheroidal head or fructification. Thus the stem is the true spawn, the head is the collection of spores in an envelope; the former is filamentous, the latter is cellular; both are capable of reproducing the species. Fungi usually grow in damp, dark situations where there is little ventilation, as in vaults, cellars, in the denser parts of woods and forests, in the hollows of trees, under decaying bark, or any other decaying matter in the dark and damp; indeed, when they grow in the light, moisture is essential to their production. If they are found on living plants or living animals, they are developed in a moist season or situation. They are very destructive, producing decay in timber and all kinds of vegetable structure, and are too well-known to the gardener and farmer under the names of mildew, rust, smut, and blight. The spores, like the seeds of other plants, require special soils in which to grow, different species being restricted to different plants, and even to different parts of the same plant. They are very minute, are constantly floating about in the air, and when they find an appropriate soil, they soon send out a large number of filaments, which extend and fructify. Bunt, or pepper-brand (*Uredo caries*), attacks the grains of wheat; smut, or dust brand (*U. segetum*), is rare in wheat, but frequently seen in barley, and more so in oats, it also attacks many grasses; rust, or red-rag (*U. rubigo*), is often found in corn and grasses; mildew (*Puccinia graminis*) also destroys wheat. *Oïdium* is the name of a fungus which is very destructive to vines; and there is one species (*O. albicans*) which is found on the mucous membrane of the mouth and throat of infants suffering from thrush. The moulds on cheese and stale bread are fungi.

Dry-rot is a well-known fungous disease, which is very destructive to the timber of some houses, ships, etc., particularly to oak. If the wood be in a damp, unventilated situation, and in a slightly acid condition (as it may be if it has not been sufficiently

seasoned, and there is a little fermentation of the remaining sap), fungi is almost sure to be developed. Small white spots first appear; from these filaments spread over the surface of the wood, and pass into the finest crevices or flaws, force asunder the tubules of the wood, completely destroy the cohesion of its tissue, and thus totally ruin the timber. Dry-rot also invades silkworms and other caterpillars, chrysalids, and insects, growing in the interior of the body at the expense of the life of the creature, and leaving only a fragile shell. Special species of fungi cause dry-rot.

Some fungi may be eaten, and are generally regarded as a delicacy. Dr. Badham, in his book on the *Esculent Funguses of England*, enumerates nearly fifty species which may be taken without danger, and gives drawings and descriptions of them. But great caution is necessary in distinguishing those that are not poisonous; for those that are wholesome in one country are not so in another, and those that may be eaten without harm by one person may cause sickness in another. *Agaricus* is the generic name by which all the species of mushrooms are collectively known. The greater number are poisonous, but the *A. campestris*, or common mushroom, may be safely eaten; indeed, it is this species which is commonly raised artificially for food. It may be recognised by its peculiar fragrant odour. The *A. oreades*, or fairy-ring mushroom, is also eatable. What other fungi may be eaten can be learned from Badham's work.



Mushroom.



Fairy-ring Mushroom.

There are few plants more numerous than Fungi with reference to genera and species. They are found in all parts of the world, even in tropical climates. Some of them have been turned to good use; but even those that are poisonous to man are useful in their place, and serve to garnish with strange forms and beautiful tints what is dead or dying. Though they constitute the lowest forms of vegetable development, they serve some purpose for Him who has made nothing in vain.

Dried plants are liable to the growth of fungi and to the attacks of many insects. If the plants are kept in a dry place, however, the growth of mould will be prevented, as it never appears unless there is damp to encourage its formation. The plants should be occasionally examined, and insect depredators destroyed, or the specimens may be carefully brushed over with a solution of corrosive sublimate dissolved in spirits of wine, in the proportion of two drachms to a pint. The bottle should be labelled *poison*, to prevent accidents.

A considerable knowledge of botany may be gained by the examination of the natural orders of our native plants, and this knowledge may be made the basis of a still more extensive study. Indeed, the pursuit of knowledge in this direction appears to be indefinite. Fossil plants which grew at an epoch in the earth's history so remote that they have now no living representatives, though strangely similar, and yet so different, are undoubtedly the ancestors from which the plants of to-day are lineally descended. The entire surface of the earth's crust must have been changed since the giant cryptogams of the carboniferous age flourished, and the sun shone upon the leafless, flowerless forests of the primeval world. What untold ages have rolled away since then, the earth meanwhile changing its form, and undergoing numerous disturbances and terrible convulsions, the effects of which are still visible in the upturned and uplifted strata, until, at last, the present glorious plant-carpet of flowers decks the smiling valleys, and creeps up the highest mountains, pencilled with beauty, burdened with fragrance, and saying to the pious and attentive student of their lives, "The Hand that made us is Divine."



Section V.

THE COLLECTION OF WOODS.

A Wood Collection Recommended.

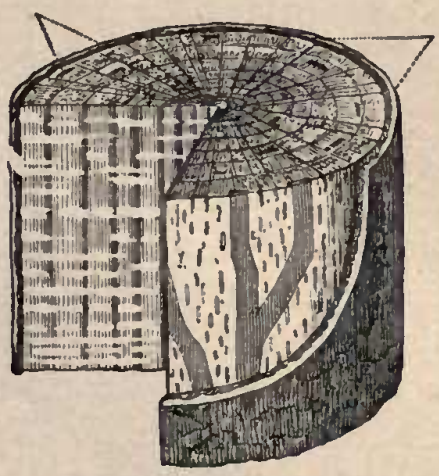
A RICH and productive field for research, and one which will be found available in practical life, is the study of the different kinds of wood used for furniture and building purposes. Wood is one of the most important and useful of natural products. It originates from the union and fibrous change of vessels which, in the first stages of the growth of trees, conducted the sap from the roots to the branches and leaves.

The trunk of a tree bears aloft innumerable branches, twigs, and buds, exposing them to the heat and light of the sun. The tree may have withstood the storms of centuries, outlived successive generations of men, and presented much the same aspect to our forefathers as it does to us. The life of man is brief indeed compared with the existence of such a grand old tree. And yet the proud monarch of the forest, with all its venerable years, must fall, to supply the

wants of man. Grandeur and beauty must bow before utility. For wood enters into the structure of our houses, it constitutes the material of our furniture, it forms part of the tools with which we work, it kindles the fire at which we warm ourselves, and it supplies us with the narrow chamber in which our bodies are laid for their long sleep till the resurrection morning. In countries where no coal is found, it possesses a value with which we are unfamiliar, for it is there the only available fuel. In the Holy Land, through the long period of Israelitish history, it was essential for the preservation of the fires on the altars of sacrifice. Our readers will remember how Abraham, when called to offer up his son, as a proof of his obedience to the Divine will and faith in the Divine promise, "built an altar, and laid the wood in order, and bound Isaac his son, and laid him upon the wood;"[1] and also how Elijah told the priests of Baal to lay their bullock on wood.[2]

How to Recognise the Wood of a Tree.

The joiner and carpenter, without any accurate scientific knowledge of vegetable structure, are able, as soon as they are shown a piece of wood, to recognise the tree of which it is the product. They do this by observing its weight and solidity, and noting also certain common and easily-perceived characteristics. The endeavour will now be made to teach a sure method of recognising woods, and also the way to prepare and properly label them for the cabinet. This study will afford an almost endless fund of instruction and entertainment.



Section of Trunk of Tree.

We have sure information for our guidance if we cut a trunk of a tree through the middle, and study the circular rings of which the stem is composed. These rings represent the successive annual deposits or growths of the wood. Our illustration shows such a trunk cut across and perpendicularly, with all its characteristic marks exposed to view. The horizontal

[1] Gen. xxii. 9.

[2] 1 Kings xviii. 23.

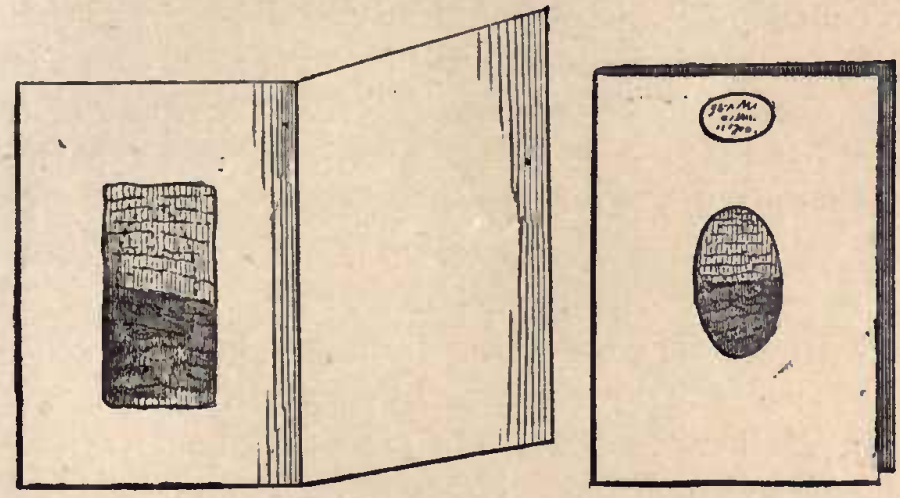
surface, called the medullary surface, exhibits a number of lighter or darker lines, termed medullary rays, radiating from the dark nucleus in the centre towards the bark. If the wood is split open, these rays appear on the longitudinal or perpendicular section as whitish streaks. Again, on the medullary surface, dark or medullary spots appear here and there; and these may be observed on the curved surface of the stem, under the bark, in the shape of broad flat branches.

The wood is penetrated by numerous finer or coarser pores, which lie most closely together towards the inner surface of each ring, because the spring-wood is more porous and full of sap than the later formed deposit of autumn; probably, also, because the wood of autumn is more compressed by the bark, which is dilated in spring. The inner, more solid heartwood (*duramen*), from which the currents of sap have been for some time withdrawn, has mostly a dark appearance, while the softer, more newly-formed rings on the outside, called sapwood (*alburnum*), have a lighter, clearer colour.

How to Prepare the Collection.

Each tree has its peculiar rings, rays, and pores, which furnish an infallible means of recognising the plant. For this purpose, it is necessary to make a thin cross section of the medullary surface of the wood with a very fine saw. If the wood be dry, it must be moistened, in order that its parts may firmly hold together. If the saw used be a good one, with a little practice smooth sections may be made without difficulty, which will be thin enough to transmit light. Large, circular, but very thin sections of the medullary surface may also be cut with the leaf-saw, but this requires practice. Fragile wood, when thus cut, is more readily handled. The wood leaflets should be as thin as post-paper. In order to prepare them in a convenient form for the collection, an octavo sheet of paper should be folded through the middle, and an elliptical hole cut in the middle of the first leaf. Behind this the section of wood must be glued down, so that it can be held up to the light and seen through. By simply folding the sheet the uncut half serves as a protection to the wood-leaflet. This will be better understood by reference to the

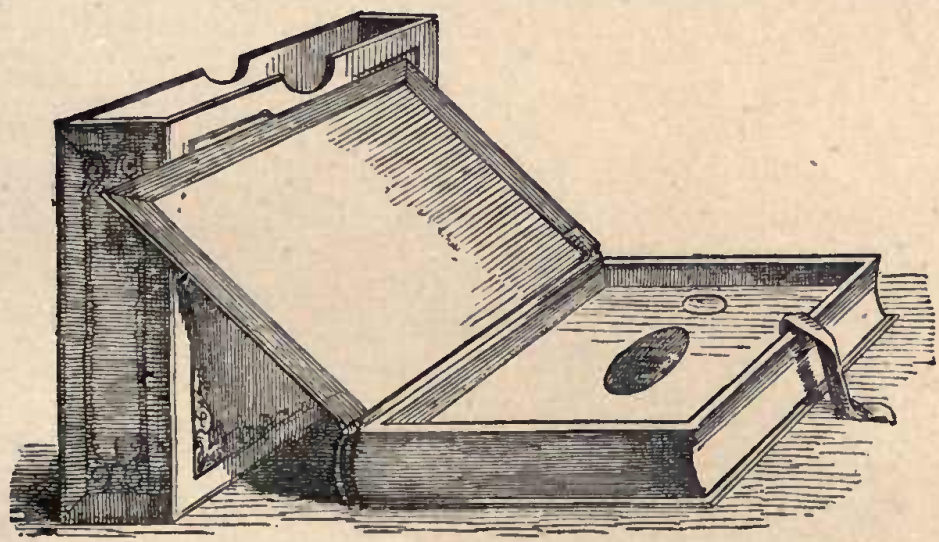
woodcut, where the wood-leaflet is seen glued behind the elliptical hole on the second page of the octavo sheet; in the other engraving,



A Leaf of the Wood Collection.

the wood-leaflet is visible through the opening, the paper being folded as it comes in the collection.

A pocket microscope will disclose sufficient of the finer texture of the wood to enable the student to determine accurately the plant to which it belongs. The name may be written outside, on the upper left-hand corner of the sheet, or it may be printed on a



Box in form of a Book, with Case, for Wood Collection.

label with a pretty design, and glued above the opening. Each sample of wood, with its sheet so folded and labelled, may be preserved in a box in the form of a book or album; this should be

placed in a case or cover. A number of preparations may thus be preserved in a small space.

Such a collection, properly and neatly made, looks as pretty as the finest album. In this manner, a young naturalist, with aptitude for such things, can easily collect and preserve the whole of the woods growing in his neighbourhood in handsome cases, as in a small library. In time, he may always have at hand, easily accessible, perfect pictures of the tree growths of his native country, with additions from those of foreign lands.

The wood collection has this advantage above all other natural history stores: it is easily made, and preserved without cost. Every time a walk is taken, branches and pieces of stems of trees may be brought home and prepared. No box or apparatus is necessary, for a piece of wood is easily carried in the pocket. Distant friends may sometimes send us packages containing woods which are otherwise difficult to obtain, and thus help to make the collection more complete and valuable. It would be interesting to many collectors to have specimens of woods referred to in Scripture, such as the oak and the cedar, the terebinth and the shittim wood, or acacia. Each of these has associations with great and good men, and with important historical events; for instance, the shittim was employed in the construction of the Tabernacle in the wilderness; the cedar in the erection of the Temples of Solomon and Zerubbabel.

From the cabinet-maker we may obtain the black walnut, which perhaps does not grow in our neighbourhood; and from the wood-engraver the golden yellow boxwood, which affords a dense and compact surface, on which even the finest lines of a picture can be drawn. The greater the care and trouble taken, the richer will be the collection. The collector will soon learn to distinguish the varieties of pine and fir, or white and yellow deal, and other building woods; also to recognise with a magnifying glass, by the structure of the wood-leaflets, the home and foreign furniture woods, such as oak, ebony, mahogany, rosewood, birds-eye-maple, etc.

A list of some of our commonest and most useful English woods, with brief descriptions of their texture, and appropriate illustrations, is given in the following pages.

THE NEEDLE WOODS.

THE CONIFERÆ, OR PINE FAMILY.

This family has evergreen, needle-shaped leaves, which make up for their want of surface by their immense numbers. The woody tissue is comparatively simple, and consists of cells which are all of one kind, with numerous fine medullary rays. The pores are loosely united, and are more numerous on the outside of the rings than on the inside; they appear to be filled with resin in a fluid state. The wood has a satin-like lustre, arising from its uniformity of tissue.

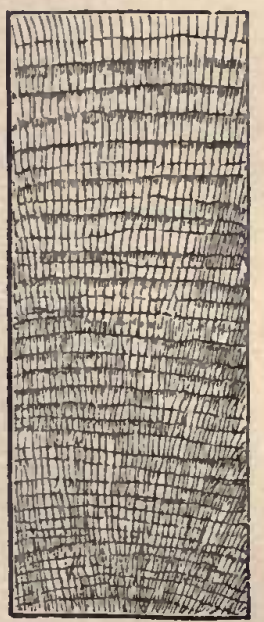
Without resinous pores.

The silver-fir (*Abies pectinata*, D. C.) has fine medullary rays, running in right lines; rings, or annual growths, distinct; duramen, white. It furnishes a whitish deal, used for flooring.

The yew (*Taxus baccata*, L.) has medullary rays like the preceding; rings, or annual zones, narrow, well-defined, and undulating; and coarse woody texture. This tree yields a very valuable timber, and lives for centuries.

With resinous pores.

The stone-pine (*Pinus cembra*) has fine medullary rays, tolerably straight; rings, or yearly growths, clear and distinct; and pores in rings sometimes near, and sometimes distant from the margin of the outer ring.



Section of Stone Pine.

The Norway spruce-fir (*Abies excelsa*, D.C.) has numerous fine straight medullary rays; rings distinct; pores near or distant from the outer limit of the rings; and duramen white. Its timber is the white deal of commerce.

The Weymouth pine (*Pinus strobus*, L.) has gradually thickening rings; pores in several loose rows, in the inner half of the rings; and duramen yellowish white. The wood of this tree is valuable for building.

The Scotch pine (*Pinus sylvestris*, L.) has some-



Section of Larch.

what undulating rings; pores within the thickest portion of the ring; and sapwood white, with brownish-red duramen. Its timber is the yellow deal.

The larch (*Larix Europæa*, D.C.) has somewhat waved, circular rings, sharply distinct towards the outer margin; and fine pores abundant towards the outside of the rings. The timber of this tree is employed in ship and house building; and the resin in the manufacture of Venetian turpentine.

THE LEAF WOODS.

The tissue of these woods is usually denser than that of the pine family, and is often irregular in its character, and penetrated by numerous peculiar groups of air-conveying tubes, or pores, called vascular openings, which are less distinct towards the outer margin of the ring.

Strong porous circles on the inner margin of the rings.

The stone-oak (*Quercus robur*, L.) has broad medullary rays, running off from the centre to the circumference of the stem in right lines, and passing through the porous circles; pores varying from large and coarse in spring, to mere punctures later in the season; duramen, or heartwood, brown; and alburnum, or sapwood, white. This is a very valuable timber tree.

The cultivated chestnut (*Castanea vesca*, L.) has somewhat fine winding medullary rays passing through the porous circles; pores in pairs at the bottom of the rings, large in the middle, and very fine towards the outside; duramen, brown; and alburnum, white. The nuts of this tree are eatable.

The ash (*Fraxinus excelsior*, L.) has numerous thread-formed fine medullary rays; angular and circular rings, agreeing with the fissures in the bark of the older stems; and pores filling almost all the space between the rings, diminishing in size towards the outside. Its wood is tough and elastic, and is used by coach-makers, and also for oars.



Section of Stone Oak.



Section of cultivated Chestnut.



Section of Ash.

The elm (*Ulmus campestris*, L.) has numerous streaked fine medullary rays; pores arranged almost in cross courses, diminishing and disappearing towards the outside of each circle; fine and spongy tissue; duramen, brown; and alburnum, white. This wood is very valuable, and is not liable to split or warp.

The false acacia (*Robinia pseudacacia*, L.) has numerous medullary rays passing through the porous circles; numerous wavy rings in the outer layers of the stem, corresponding to the outer fissures of the bark; pores at first fine, thick, and close, middle-sized in the centre, and lastly, perforating the whole of the ring, which resembles a sieve. The tissue is visibly porous. This tree is cultivated as an ornament, and for its excellent timber.

The bird-cherry (*Prunus avium*, L.) has very numerous fine, straight medullary rays; rings represented by a beautiful brown circular autumnal line; pores fine, first lying near each other in dense streaks, then perforating the wood within the rings, and interrupted by porous bands. The fruit is used in the manufacture of cherry brandy.

The plum (*Prunus domestica*, L.) has numerous straight medullary rays, of one breadth up to the middle; finely-undulated rings, mostly clear; pores forming an uninterrupted line at the bottom, then



Section of Plum Tree.

scattered and very fine, almost disappearing; duramen, bluish-brown red; and alburnum, whitish yellow. The fruit of the plum is valuable for domestic use; prunes are the dried fruit.

The wild cherry (*Prunus padus*, L.) has numerous medullary rays, gently curved to the outside; the outer rings only faintly indicated; fine pores, in numerous rows, filling out almost the entire breadth of the rings, the inner densely, the outer evenly arranged; and broad alburnum, yellowish white.

The alder buck-thorn (*Rhamnus frangula*, L.) has gradually diverging fine medullary rays; numerous fine pores close together at the base of the rings, then rapidly diminishing, so that the outer third of the rings is almost free from them; duramen, yellowish red; and alburnum clear yellow.

Inner margin of the rings without strong porous circles.

The beech (*Fagus sylvatica*, L.) has broad, fine, and very fine medullary rays, the first often bending or breaking off; the outer margin of the rings is beautifully undulated and notched; fine pores, diminishing from the base of the rings to their margin, which is totally devoid of pores. The timber is hard and valuable.



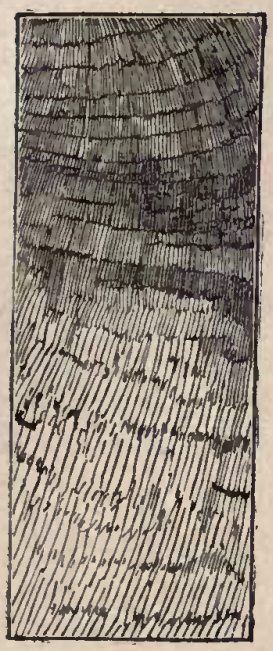
Section of Beech Tree.



Section of Pear Tree.

The pear tree (*Pyrus communis*, L.) has somewhat winding fine medullary rays; autumnal line faint, but determined by the fine-pored spring line near it; and numerous pores equally scattered. This wood is sometimes used by engravers.

The apple tree (*Pyrus malus*, L.) has very fine medullary rays, sometimes interrupted; spring line indistinct; and numerous fine pores, as in the pear-tree. All the cultivated varieties of apple are obtained by grafting with the native species.



Section of Apple Tree.

The hawthorn (*Sorbus aria*) has fine gently-curved medullary rays; streaked and banded rings; and very fine pores. The timber is reddish white.

The whitethorn (*Cratægus oxyacantha*) has numerous very fine medullary rays, first in light streaks, then granulated, and lastly, striped and passing through the rings; and red, yellowish white wood.

The mountain-ash (*Sorbus aucuparia*, L.) has numerous very fine slightly curved medullary rays; rings bounded by a yellowish brown fine autumn line; very fine streaked pores, penetrating the rings; duramen, reddish brown; and alburnum, reddish white.



Section of Boxwood.

The spindle-tree (*Euonymus Europæus*, L.) has numerous very fine, somewhat curved medullary rays; fine but well-marked rings, which are often double; and fine symmetrical pores, divided into bands.

The box-tree (*Buxus sempervirens*) has numerous very fine straight medullary rays; clearly defined, slightly undulating, and prominent rings; very fine pores appearing on the inner two-thirds of the rings. The wood of this tree is light sulphur yellow, and uncommonly hard, not splitting under the knife or graver; it is therefore the most suitable of all known woods for engraving. The polished surface of the boxwood is covered with a thin layer of whitening, on which the artist draws his picture. The engraver then graves or digs out all the wood between the lines of the drawing, including its finest points, so

that they remain raised. The wood thus retains on its surface the picture which the designer and engraver wish to be represented; and from it impressions are taken on paper by the printer. Box-wood is imported in pieces about four feet long and ten inches in diameter, from Smyrna, Constantinople, and the Greek Islands.

The maple (*Acer campestre*, L.) has numerous straight, medium-sized medullary rays, often wedging themselves out; rings indicated by a small autumnal line, which is often penetrated by clear and dark rays; numerous coarse pores, nearly equal in size, but finer towards the margin, evenly distributed through each wood ring. The timber of this tree is reddish in colour, and it burns clearly.

The sycamore (*Acer pseudo-platanus*, L.) has slightly diverging medullary rays, penetrating through the fine autumnal lines; and fine, equally divided pores. This wood is used in machinery, and for the manufacture of charcoal.



Section of Small-leaved Linden.

The small-leaved linden (*Tilia parvifolia*) has fine medullary rays, growing stronger by degrees; and pores varying from fine to very fine, which separate and disappear towards the outside of each wood layer.

The horse-chestnut (*Æsculus hippocastanum*, L.) has very small, finely curved medullary rays; well-defined faintly yellowish rings; and very fine pores, at first united in streaks, then equally diffused, and afterwards disappearing. This is a fine tree, much valued for its beautiful appearance, its cones of flowers, and the perfect shade which it affords.

The alder (*Alnus glutinosa*) has broad, straight medullary rays; beautifully undulated rings; fine pores, increasing in size and flowing together into various figures; and coarse, spongy tissues. The wood is reddish in colour.

The hornbeam (*Carpinus betulus*, L.) has numerous broad straight medullary rays; broad waves of dark autumnal streaks; and numerous pores uniting into different figures, running parallel with the medullary rays.

The walnut tree (*Juglans regia*, L.) has moderately fine medullary rays; fine autumnal line; slightly undulating rings; gross pores, almost equally divided; and duramen dark brown. This tree lives from nine hundred to one thousand years.



Section of Walnut Tree

The dogwood (*Cornus sanguinea*, L.) has moderately fine straight medullary rays, which often wedge themselves out; small autumnal and spring streaks penetrating the porous lines; and confluent fine pores, mostly in streaks.

The silver-willow (*Salix alba*, L.) has numerous very fine medullary rays; and fine-pored autumnal streaks. In the spring of the year the pores are medium-sized and nearly equally divided.

The silver-poplar (*Populus alba*, L.) has numerous very fine medullary rays; faintly marked autumnal line; and undulated pores, fine in the first third, very fine in the second, then almost disappearing.

The aspen (*Populus tremula*, L.) has fine, feebly diverging medullary rays; finely shaded, beautifully rounded autumnal line; and pores at first in a very fine line, then equally divided, and often flowing together. This tree is remarkable for the extreme mobility of its leaves, the least current of air producing agitation amongst them.

The birch (*Betula alba*, L.) has fine somewhat serpentine medullary rays; the porous tissue of the fine autumnal line scarcely interrupted; the rings in wide, gentle curves; and the pores in scattered groups. The oil from the bark of this species of birch gives the peculiar odour to Russia leather.

The elder (*Sambucus nigra*, L.) has numerous finely curved, small medullary rays; fine pores; clearly three-streaked rings, the spring streak plentifully punctured, the middle one less so, and the autumn one besides the fine pores, showing streaks without them.

The hazel-nut (*Corylus avellana*, L.) has a clearly drawn, fine, and rounded autumnal line; broad medullary rays, passing through the porous groups; and pores at first dense and fine, then radiating and branching in rows like a little tree, the wood rings breaking through between the radii.

From this list of trees it is evident that the Creator has provided ample variety for different uses. Some trees supply food for man and other animals; while others furnish wood suitable for various purposes. Indeed the resources of God in creation are boundless; and His care is over all His works. But it should always be remembered that the God of nature is also the God of grace; and that He who built the mountains, and made the trees after their kind, is the God of the Bible who asks our faith and love, and promises the pardon of sin, the guidance of the Holy Spirit, and, when life's brief day is over, eternal life with Him for ever in the New Jerusalem, where the tree of life grows whose leaves are for the healing of nations, through the merits of our Lord and Saviour Jesus Christ.





Section VI.

THE MINERAL COLLECTION.

The Continual Changes in the Mineral Kingdom.

THE crust of this vast globe is continually changing; for matter, whether animal, vegetable, or mineral, has its laws of growth or accretion, decay or decomposition, and re-formation. If the earth is looked at through the countless ages which geology contemplates, the land seems to lose its popular attribute of fixedness, and becomes as changeable in its aspect as the flowers and forest trees which adorn its surface. Some of the changes in the mineral kingdom, though by no means the most important ones, we may daily see taking place before our eyes.

Every shower that falls causes the wearing away and removal of rocks, soils, and all surfaces exposed to its action. By entering the pores of rocks the falling water softens and loosens them, and thus renders them more easily subject to the influence of currents of wind and water. On every roadside we see how the fine soil of the banks is washed down, and then borne away by the brooklets.

Every stream does the work of destruction by tearing up the soil along its bed and sides, and carrying this soil away to lower situations. The foaming mountain torrent breaks down the rocks over which it rushes, carrying the fragmentary rubbish with it into the valleys below, where it becomes calm and quiescent. Here it receives numerous tributary streams, each bearing into its bosom a fresh contribution of gravel, sand, and silt. Now, when a river thus freighted with sedimentary matter enters a lake, it is soon filled up; when it flows on to the sea, it in time bars its own exit. Lakes thus filled up become first marshes, and afterwards arable land. Islands are formed where the rivers enter the sea. The name given to these fresh-water deposits is alluvial (Latin, *ad-luo*, to wash against). The Nile Delta, the Sunderbunds at the mouths of the Ganges and Irrawaddy, and the swamps of the Mississippi, Amazon, and Niger, are all alluvial deposits on a large scale. The earthy materials of which they are composed have been transported from the interior of the countries through which the rivers flow for hundreds or even thousands of miles. If they are examined, they will be found to be deposited in successive layers, forming the stratification which is so distinctive a feature of rocks produced by the action of water. The layers consist of mud, clay, and sand, deposited when the river flows quietly, gravel deposited during seasons of flood, inclosing remains of plants and animals peculiar to the country through which the river has passed, which thus become embedded in the newly-formed strata. In this way the turbid waters of the Ganges discolour for many leagues the waters of the Bay of Bengal, and year after year deposit portions of the Himalaya Mountains, fifteen hundred miles away. And the clayey mud of the Chinese rivers tinges the waters of the Yellow Sea for upwards of fifty miles from land, having changed it into a shallow basin in the centre and turned its shores into fertile rice-fields.

Meantime, the sea is continually devouring some shores and retiring from others. In the former case the rocky particles of the cliffs have been loosened by the action of wind and rain and briny spray. The waves, especially in stormy weather, shake and wash them down, and bear them out to sea. Thus coasts are being continually

undermined and destroyed, and acquire that rugged and ruinous appearance which they generally present. Where the rock is soft, the progress of the angry and contentious waters is proportionably rapid; but if it be hard and compact, the combat between the sea and the land may be kept up for thousands of years. The irregularity of coast-line which marks the shores of all countries has thus been produced in course of ages. "The sea," says Sir John Herschell, "is constantly beating on the land, grinding it down, and scattering its worn-off particles and fragments, in the state of mud and pebbles, over its bed. Geological facts afford abundant proof that the existing continents have all of them undergone this process, even more than once, and have been entirely torn into fragments, reduced to powder, submerged, and reconstructed."

Ever since that period of the creation when "God said, Let the waters under the heaven be gathered together unto one place, and let the dry land appear: and it was so,"[1] the balance between land and water has been preserved. For God then "shut up the sea with doors," and "brake up for it" His "decreed place, . . . and said, Hitherto shalt thou come, but no further: and here shall thy proud waves be stayed."[2]

But, besides the agency of water in causing destruction and decay, and partial re-formation and renovation, there is also the chemical influence of the atmosphere, which silently and imperceptibly produces, in the course of ages, by far the greatest amount of change. Iron, clay, and lime, enter into the composition of most sandy and flinty rocks, acting as a cement, and binding their particles together. The lime in such rocks has a tendency to unite with the carbonic acid in the rain-water which falls upon them, and the iron combines with the oxygen of the atmosphere. The cement thus becomes loosened, the rocks fall to pieces, and are then easily broken down by wind, rain, frost, and other mechanical agents.

By means of this chemical influence of the atmosphere, and the various aqueous agencies already mentioned, a continual process of decay and disintegration is going on in the mineral kingdom all over the earth. Were there nothing to counteract these influences,

[1] Gen. i. 9. [2] Job xxxviii. 8, 10, 11.

all the land now above the ocean, including even the mountains, would ultimately be buried beneath the waters, and the whole earth become one vast saline marsh. The ocean, however, is restrained within its boundaries by the will of the Creator. It is amongst the mysteries of Divine government, which no human science can fathom, that God should have chosen the volcano and the earthquake, among His other agents, for the preservation and re-elevation of the land. Earthquakes, as is evident from the disturbed state of the strata, have convulsed the earth at former epochs, even in spots where nature has been quiet for ages; and it is certain that they have carried ruin and devastation to every part of the globe.

The aqueous rocks were originally deposited horizontally; they do not now, however, lie one upon another regularly, like the coats of an onion, but are uplifted and torn, so that they dip or strike into the earth at all angles, from one degree to ninety degrees. In fact, the unevenness of the earth's surface, from the earliest dawn of creation, has been caused, either suddenly by the volcano or the earthquake, or slowly by gradually elevating processes; so that new land has arisen above the ocean as fast as the old land has been disintegrated and fallen below its surface.

But this dark cloud of God's providential dealings with our globe has not been without its silver lining. To His creative and re-creative operations the psalmist's words are applicable: "Thy way is in the sea, and Thy path in the great waters, and Thy footsteps are not known."[1] Wisdom and goodness are to be seen even in these violent occurrences. These convulsive upheavals of the earth's strata have brought to the surface many valuable hidden minerals, such as iron, copper, and coal, which otherwise would probably have remained for ever unworkable by man. The grandeur, beauty, and fertility of the land have also been greatly increased by the intermixture of the various soils. Every earthquake which in bygone times has fractured and dislocated the strata, and every change of level which has elevated the bed of the ocean or depressed the land below its surface, has contributed more or less to bring about that admirable admixture of sand, clay, lime, and other materials, which now forms the earth's

[1] Psa. lxxvii. 19.

upper covering, the fruit-bearing soil, which is the inexhaustible source of national strength and prosperity.

What a Mineral Collection should contain.

Even dumb stones may be made to speak, and narrate the story of bygone ages, when the researches of science are brought to bear upon them. Whatever their composition, or wherever found, each one has a history of its own, written in characters only to be understood by the aid of the geologist and mineralogist.

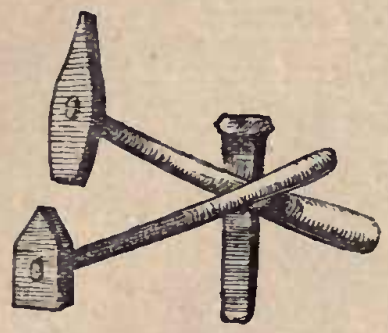
It is obvious that all the changes of the earth's surface, and varying relative positions of land and water, could not occur without requiring corresponding differences in the structure of plants and animals. Some of these became extinct, and others appeared from time to time, as the land became fitted for their reception. All this will be proved by examination of the strata, and their fossil impressions of plants and animals, such as ferns, shells, ammonites, together with the crystals, metals, and other wonderful forms of the mineral world. A mineral collection should therefore contain the following: Specimens of various strata of rocks, those that have been due to the action of fire, and those due to the action of water; those without any signs of primitive life, either of plants or animals; those that contain remains of ancient vegetable and animal existence; and minerals and metals of all kinds.

Now that railways, in their cuttings through hills and mountains, frequently allow a glance into the interior structure of the earth and the contents of its strata, and carry travellers speedily from one country to another, mineralogical and geological researches are more commonly and energetically prosecuted than ever. It is hoped the following instructions in practical mineralogy and geology will prove useful as an introduction to this branch of Natural Science.

Tools used for obtaining Minerals and Fossils.

The tools necessary for obtaining specimens are a steel hammer and chisel, which any country blacksmith can make, or which can be readily bought in town. The head of the hammer should be broad and thick at one end, and the other shaped into a short, well-defined wedge. When a mineral or fossil is obtained and

reduced to a portable size, it should be carefully wrapped in paper, and placed in a bag. The name of the locality where the specimen was found, and of the rock in which it was imbedded, should be written on the outside of the bag. Quarries, mining works of all kinds, road-cuttings, and brick-pits should be visited. The workmen in these places will gladly keep for the collector, when they come to know him, anything that may turn up in making their excavations; but it is more instructive to hunt for your own supply. Fossils which are broken may be strengthened or repaired with a solution of strong gum or liquid glue.



Geological Hammers and Chisel.

How to Preserve the Specimens.

The specimens should be placed in separate boxes, which are easily made of strong paper or thin pasteboard. Two kinds of boxes are usually made, one double the size of the other, so that the former will hold the latter when empty. These pasteboard boxes may also be placed in a wooden box, sufficiently large to hold four great, or eight small boxes side by side, or altogether sixteen great, or thirty-two small pasteboard boxes. Each specimen should have the current number of the collection attached to it, and the descriptive label should be fastened at the bottom of the box. When the collector has filled the wooden boxes with small pasteboard ones, the label with the name of the family or class should be glued on the outside of the drawer containing the whole of them.

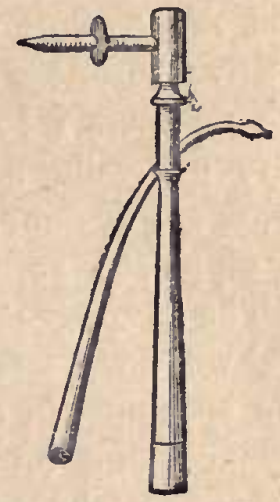


Boxes for Specimens.

How to Recognise and Analyse Minerals

Much practice and considerable skill is necessary in recognising

minerals with certainty. They are determined by their form, colour, hardness, specific gravity, transparency, streak, and their chemical constituents. For this purpose some simple, inexpensive vessels and materials are required, the use of which will prove easy and highly interesting and instructive. The collector need not be deterred by such unusual things as blowpipe, borax, etc., from examining the glittering ore, the glass-like crystal, or the hard stone which he has obtained. The following are the principal necessaries:—a blowpipe; a spirit lamp; a platinum spoon; a piece of unglazed porcelain or earthenware; a large magnet; an agate mortar; a pair of scales; one dozen reagents; hydrochloric and sulphuric acids, in glass-stoppered bottles; borax, soda, saltpetre, and phosphoric acid (the first three must be kept in boxes, and reduced to a fluid by the blowpipe); charcoal.



Blowpipe.

The *form* of a mineral, especially of its crystal, teaches many things respecting its nature. But regularly-formed and therefore easily recognised crystals are seldom found; minerals being met with either in masses, or so imperfectly crystallised that the student has to fall back on other characters. There are, however, several works on mineralogy which show the forms of different crystals, reference to which will afford sufficient guidance to the beginner.

The *colours* of minerals, if they are essential constituents of them, are good distinctive characters; but colour is very frequently the result of the accidental presence of oxides of iron, manganese, chrome, or some other colouring matter. In such cases, crystals which, when pure, are colourless, as, for example, the diamond and quartz, become beautifully tinted. If the colouring ingredients are chemically combined with the mineral, the transparency of the crystal is not interfered with; but if the intermixture is merely mechanical, the crystal becomes more or less opaque. In either case, however, the colour is accidental, and the mineral itself can only be regarded as a variety.

The *hardness* of a mineral is a very useful and trustworthy

character in determining its species. This particular is established with exactness by comparing it with the known hardness of other minerals. A mineral will always furrow one less hard than itself; and the hardest will scratch the surfaces of all the others. The relative hardness of minerals is now usually denoted by numerals, the numbers 1 to 10 being employed. The following is the scale very generally adopted:—1, talc; 2, gypsum, or rock salt; 3, calcspar; 4, fluor spar; 5, apatite; 6, felspar; 7, quartz; 8, topaz; 9, sapphire; 10, diamond.

The *specific gravity* of a mineral is a highly important characteristic, and will often serve to identify it. This is obtained by first weighing the specimen in the usual manner in the atmosphere, in a delicate balance, and afterwards weighing it when immersed in distilled water. If the weight of the mineral in air is divided by the loss of weight it sustains when weighed in water, its specific gravity is found, or its weight, as compared with the weight of its own bulk in water. Thus, when it is said that the specific gravity of gold is 19, it simply means that gold is nineteen times heavier than water, bulk for bulk.

A mineral is called *transparent* or *pellucid* when objects can be seen through its substance; if the objects are only indistinctly seen, the mineral is said to be semi-transparent.

There are two modes of determining the chemical constituents of minerals,—the dry and the moist.



Blowpipe Analysis.

The Dry Method.—A small fragment of the mineral is exposed to great heat on a piece of well-burnt charcoal, which is held in the left hand, whilst the flame of a candle or spirit-lamp is directed upon it by means of a blow-pipe. The beginner must not operate on a piece larger than a pin's head, which should be placed in a little hole made in the charcoal. The wick of the lamp or candle should

be bent in the direction of the object to be examined; and the operator should be able to rest both arms against the edge of a table. The flame must be brought to a point by means of a gentle continuous stream of air passed through the blowpipe from the mouth, the point of the blowpipe being inserted about a tenth of an inch into the flame. When the flame is properly manipulated, though reduced in size, the heat is greatly increased. It consists of two parts, a hollow cone of yellow light enclosing a blue one. The greatest heat is at the point of the blue flame, which is called the reducing flame, because it deoxidises the substances exposed to it, and is capable of melting a great number that are not fusible in the outer or oxidising flame. It requires some practice to be able to keep up a continuous stream of air through the blowpipe, and produce a properly pointed flame. During the operation the cheeks should be continually distended with air, which must be inhaled through the nostrils, through which also breathing must be carried on. The behaviour of the substance under treatment must be carefully noted while the point of the flame is made to play upon it.

If it be difficult to fuse the mineral, it should be mixed with borax, carbonate of soda, or some other flux, when it will melt into a more or less transparent mass, or a colourless or coloured enamel, according to its nature. For example, cobalt, when fused with borax in a platinum spoon or furnace, produces a fine clear blue glass; and manganese so treated yields a beautiful green glass. After some time, the glass or product of the fusion of the mineral with the flux should become transparent; but if it remain opaque, it must be broken in pieces, the platinum spoon cleaned, and the operation of melting repeated.

The Moist Method.—A fragment of the mineral to be treated is moistened or dissolved with distilled or clean rain-water; and the solution is aided by heating the fragment over the spirit-lamp. Or a piece of the mineral about the size of a pin's head is crushed to powder, and moistened with dilute sulphuric acid. If effervescence follows, it indicates the presence of lime, generally in the form of a carbonate, the effervescence being produced by the escape of

carbonic acid gas. For instance, if a piece of common limestone or chalk is moistened with sulphuric acid, usually termed oil of vitriol, decomposition ensues, carbonic acid gas escapes with effervescence, and is replaced by sulphate of lime, the sulphuric acid combining with the lime in the place of the carbonic acid gas which has been set free.

Care must be taken, while experimenting with acids, not to drop any on the clothing; for, if this is not attended to, it will be discoloured with spots and burnt into holes.

It is recommended that the ores containing sulphur, lead, and antimony should be the first objects of analysis by the blowpipe; afterwards, analysis with fluxes and with sulphuric acid may be undertaken. Only first-class articles should be purchased.

The Classification of Minerals.

Minerals may be divided into four classes, according to easily-ascertained characteristics, as follows:

a. Saline minerals, or such as are soluble and impart a taste to water.

b. Earthy minerals, insoluble in water, tasteless, and incombustible at a white heat.

c. Metallic minerals, having a metallic lustre when scratched, or reducible to a metallic state by the blowpipe.

d. Combustible minerals, soft, yielding easily to the knife, and more or less burned when submitted to the blowpipe.

It must first be ascertained by experiment to which of the above classes the mineral under treatment may be assigned, and afterwards the minuter divisions, or the family, genius, species, and even the variety, to which it belongs.

a. Saline Minerals.

These minerals are found in a natural state; but they are easily procured from the druggist, by whom they are artificially made; they are all soluble in water.

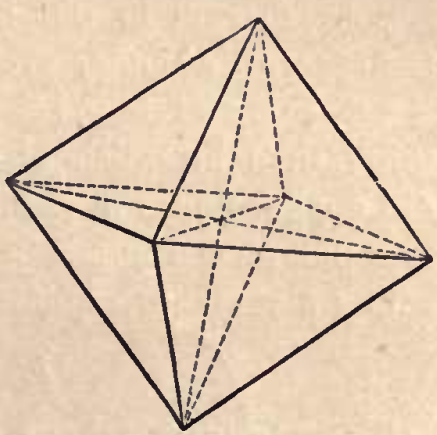
1. Common Salt (*Chloride of sodium*) is a naturally abundant, important, and useful mineral. It exists in sea-water salt lakes

and brine springs, besides being found in a crystalline form in extensive beds or deposits in many countries; for example, Poland and Hungary, where the mines are very extensive. The salt obtained from mines is much purer and whiter than that found on the surface of the earth; and when the mines are lighted by lamps and torches, they present a splendid appearance. In the mines of Northwich, in Cheshire, the salt is found in masses five to eight feet in diameter, and is nearly pure. Salt crystallises in cubes, and crackles before the blowpipe or when thrown into the fire. It is necessary to the health of man and animals, and is taken more largely in a natural form than any other mineral.

2. SAL AMMONIAC (*Muriate of ammonia*) is found in radiated, tough, yellowish masses; has a sharp taste; and volatilises in strong clouds before the blowpipe. It is a volcanic product, and occurs in such regions as Vesuvius, Etna, and the Sandwich Islands.

3. GLAUBER SALT (*Sulphate of soda*) effervesces, or crumbles to a greyish white powder on exposure to the air; is cooling, saline, and bitter to the taste; and forms long prismatic crystals when recently prepared. It is found as an efflorescence in parts of Austria, the Tyrol, and the United States.

4. ALUM (*Sulphate of alumina*) invariably occurs in crystals of eight equal and equilateral triangles; has a sweet, astringent taste, and, when exposed to the heat of the blowpipe, melts easily to a loose, spongy mass. It is found in Saxony, Silesia, Sweden, Italy, and in the alum-shale at Whitby, Yorkshire.



Alum Crystal.

5. SALTPETRE (*Nitrate of potash*) is met with on the surface of the soil in the form of a thin, white, semi-transparent crust, or in tufts of minute crystals, also on the walls of old buildings, in cellars and caverns. Cooling and saline to the taste. When mixed with charcoal, it makes a lively explosion. Used in the manufacture of gunpowder, fireworks, and glass. Large quantities are collected from the ground in India, Egypt, and Spain during the hot weather succeeding periodical rains.

6. Borax (*Borate of soda*) is soluble, has a sweetish, alkaline taste; fuses at a moderate heat; when moistened with sulphuric acid gives the blowpipe flame a green tinge, and crystallises in white, transparent, modified prisms. It is used as a flux in analytical chemistry and in manufactures; and is found in Thibet and Persia.

7. Soda (*Carbonate of soda*) has a sharp, alkaline taste; effervesces with an acid; effloresces on exposure to the air; and colours the blowpipe flame yellow. It is found in Hungary and Egypt.

8. Epsom Salts (*Sulphate of magnesia*) has an unpleasant, saline, bitter taste; small, brittle, needle-shaped crystals, and effloresces slowly. It is very extensively used in medicine. Occurs in Switzerland, Bohemia, and England.

9. White Vitriol (*Sulphate of zinc*) is transparent; dirty white in colour; has an astringent, metallic, and nauseous taste; and before the blowpipe swells into an infusible mass. It is useful in cases of poisoning, being a very prompt and powerful emetic. It is found in old mines.

10. Green Vitriol (*Sulphate of iron*) has an astringent taste; before the blowpipe becomes brownish red; and colours borax dark green. Occurs in old mines in bluish green to yellowish white, transparent, oblique, prismatic crystals.

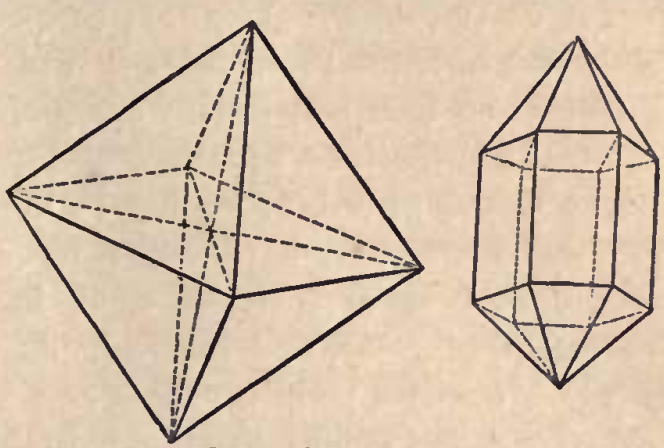
11. Blue Vitriol (*Sulphate of copper*) under the blowpipe becomes white, then brownish black, finally yielding copper. It is found in old copper mines in rich, deep blue, oblique, prismatic crystals. An iron nail placed in a solution of sulphate of copper becomes covered with a metallic precipitate of copper.

b. Earthy Minerals.

These minerals have no metallic lustre; are incombustible, of different degrees of hardness, and mostly light in colour; their weight is similar to that of common stones.

12. Quartz (*Silica*) is found in double six-sided pyramids or dodecahedrons, or in oblique six-sided prisms with six-sided terminations; it is commonly called rock-crystal; strikes fire with steel; scratches glass easily; and is infusible before the blowpipe, but, with four parts of soda, fuses into a glass. Its degree of hardness

is 7, and specific gravity 2·6. The crystals are transparent, white, and sometimes coloured. It occurs in united masses on the roofs of caverns and in clefts of rocks, covered with six-sided pyramidal points. Quartz is widely diffused throughout nature, and is a constituent of the granitic and older rocks.



Quartz Crystals.

The following are examples of quartzose minerals: *Amethyst*, a violet crystal of quartz; *agate*, or Scotch pebble, quartz with coloured bands or clouds; *chalcedony*, a semi-transparent, bluish white quartz; *onyx*, a striped chalcedony, formed of alternate layers of brown and white; *camelian*, a variety of chalcedony of a reddish colour, having a slightly shining lustre when broken—it is much used for seals; *chrysoprase*, a light green quartz without regular shape; *Scotch topaz*, an opaque yellow quartz, coloured in different shades by oxide of iron; *rose quartz*, which owes its colour to the presence of oxide of iron; *flints* are impure nodules of quartz; *sandstone* is consolidated quartz grains, generally coloured reddish or yellowish brown by oxide of iron; *gravel* is water-worn pebbles of quartz; *pudding stone* is gravel cemented together by clay, impregnated with oxide of iron; and the useful *common sand* is loose grains of quartz.

12*a*. OPAL is a siliceous mineral closely allied to quartz, resembling glass; it is of a pale bluish or yellowish tinge; is remarkable for its brilliant play of red, brown, and yellow colours; and crackles before the blowpipe. Its degree of hardness is 5 to 6, and specific gravity 2·2.

12*b*. OBSIDIAN is a volcanic substance resembling common green-black bottle glass; is brittle, opaque, and swells and froths before the blowpipe, fusing into a transparent glass.

13. PUMICE-STONE is bladdery or vesicular, full of holes, spongy, fibrous, grey, and whitish. It may be called the stone-foam of

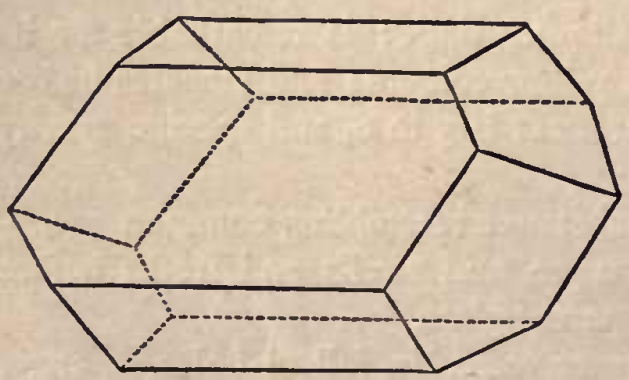
volcanoes, or the froth of lava, which has been so suddenly cooled as to preserve its spongy form.

14. Clay (*Alumina*) is, next to quartz and lime, one of the most abundant of natural minerals; it is plastic, earthy, emitting a peculiar odour when breathed upon; opaque, very variously coloured, owing to the decomposition of felspar and quartz; and before the blowpipe burns yellow or red, according to the iron it contains. Its specific gravity is 1·2, and hardness 1 to 3. It is contained in roofing-slates, and is extensively used in the manufacture of pottery, porcelain, pipeclay, and meerschaum pipes.

15. Mica is a whitish yellow and brown, or green and colourless substance, and occurs in six-sided tables, leaves, and scales, forming very thin, elastic, flexible plates, which can be separated with a penknife. The glistening, scaly, and transparent substances found in granite are mica. In Siberia, mica is sometimes found in large crystals, and is there split into plates and used as window glass. On exposure to great heat mica becomes white and opaque: its specific gravity is 3·8, and hardness 2 to 3. Mica is a silicate of alumina and lime, and is found in the granite, gneiss, and mica slate of the Hartz Mountains of Germany and the Highlands of Scotland.

16. Talc is a transparent, foliated, soft, shining, non-elastic mineral, greasy to the touch, resembling mica. Before the blow-pipe the laminæ turn white, but remain infusible; its specific gravity is 2·7, and hardness 1. Talc is a silicate of magnesia, and enters largely into the composition of the earlier slates.

17. Felspar is a very abundant mineral, which crystallises in oblique prisms; nearly as hard as quartz, with a similar lustre, but can be scratched with a knife; is generally white or flesh-red in colour; and, when mixed with borax, melts before the blowpipe into a clear glass. Lime felspar, or Labradorite, however, is an exception to this, for it will not melt. The



Felspar Crystal.

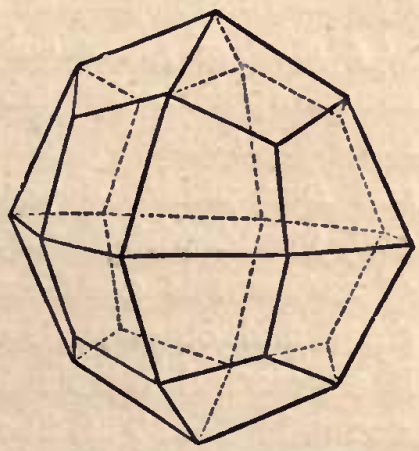
specific gravity of felspar is 2·6, its hardness 5. Felspar is a silicate of alumina and potash; but the white felspar of Cornwall, or *albite*, is a silicate of alumina and soda. *Adularia*, or moonstone, occurs in beautiful white crystals, and is composed of the purest felspar. Granites and allied rocks consist largely of quartz, felspar, and mica.

17*a*. The TURQUOISE, to which fashion attaches so high a value, is opaque, and owes its greenish blue colour to the presence of a very small quantity of copper. Its specific gravity is 2·8 to 3, and hardness 5 to 6. The turquoise is principally found in the Peninsula of Sinai, the mining district of the ancient Egyptians, but it also occurs in alluvial clay in Persia.

17*b*. The LAPIS-LAZULI (*lazulite*, azure stone), from which ultramarine blue is prepared, is a beautiful mineral of different shades of blue, found in China, Persia, and Siberia. It swells before the blowpipe without fusing, its specific gravity is 2·8, and its hardness 5·5 to 6.

18. ZEOLITE (Greek, ζέω, to boil, in reference to its behaviour before the blowpipe) froths and boils violently when heated; is radiated and fibrous in structure; and occurs in acicular or needle-shaped crystals of a beautiful pearly lustre, usually grouped in divergent tufts.

18*a*. LENCITE, or white garnet, is commonly found in larva in trapezohedral crystals of a dirty white colour. Its specific gravity is 2·5, and its hardness 5·5. The crystal is derived either from the cube or the rhomboidal dodecahedron as a primitive.



White Garnet Crystal.

19. AUGITE (Greek, αὐγή, radiance) occurs frequently in all the earlier igneous rocks, in oblique prisms, terminating in two surfaces of a dark green colour. Before the blowpipe it melts to a glass. Its specific gravity is 3·3, and its hardness 5 to 6. *Basalt*, *greenstone*, and *trap* are igneous rocks of a crystalline texture, composed chiefly of augite and felspar.

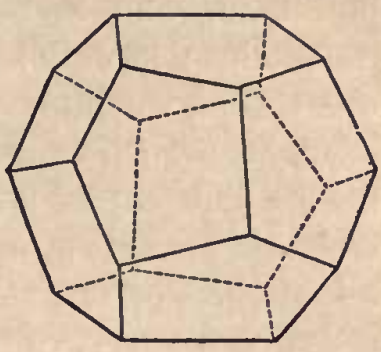
20. HORNBLENDE occurs in oblique prisms, terminating in three

surfaces; it is black or greenish-black in colour. There are several varieties of hornblende, distinguished by the character and colour of their crystals. When in long green prisms and fibrous-rayed masses, it is called *actinolite* (Greek, *ἀκτίς*, a ray, and *λίθος*, a stone); when in long white, greyish-fibrous crystals, with bright and glassy surface, it is termed *tremolite*, or *grammatite;* when in long, very delicately-formed, flexible, flax-like fibres, it is called *asbestos*, or incombustible flax. This last substance is a truly remarkable one. Although a single fibre can be fused into a white enamel, in mass it is capable of resisting the action of ordinary fire. It is also so soft and pliable that it can be spun and woven like flax; and cloth thus made may be cleansed when dirty by being burned. The ancients burned the bodies of their dead in asbestos cloth, in order to preserve their ashes; and the modern Greenlanders use it for lamp-wicks. Charlemagne is said to have possessed an asbestos table-cloth, which he was in the habit of throwing on the fire after dinner, in order to cleanse it, and also to amuse his guests. Its hardness is 1 to 4. Veins of asbestos occur in serpentine rocks, Cornwall, and at West Chester, Chester County, Pennsylvania.

21. SERPENTINE (so called from the supposed resemblance of the mineral to the speckled skin of a serpent) is a silicate of magnesia, of a mottled green colour. It is now generally admitted to be a metamorphic rock, perhaps an altered dolomite or magnesian limestone. It can be scratched with a knife, is greasy to the touch, and susceptible of polish. It burns white before the blowpipe, and, mixed with borax, melts to a green glass bead. Its degree of hardness is 3. Common serpentine is found at Portroy, Banffshire, and other parts of Scotland and its isles. Noble serpentine is a beautiful marble used for various ornamental purposes; it occurs in Glen Tilt, Scotland, and at the Lizard, Cornwall.

22. GARNET is found imbedded in gneiss, mica slate, hornblende slate, and other crystalline rocks, usually in dodecahedron or twelve-sided crystals; it is red, brown, and black in colour, and easily melts before the blowpipe into a brown black slag. Its specific gravity is 3·4, and its hardness 6 to 8 Common garnets

are abundant in Cornwall, Cumberland, and Scotland. Clear deep-red garnets are regarded as rich gems, and are much used as ornaments. The garnet is the Roman *carbunculus*.

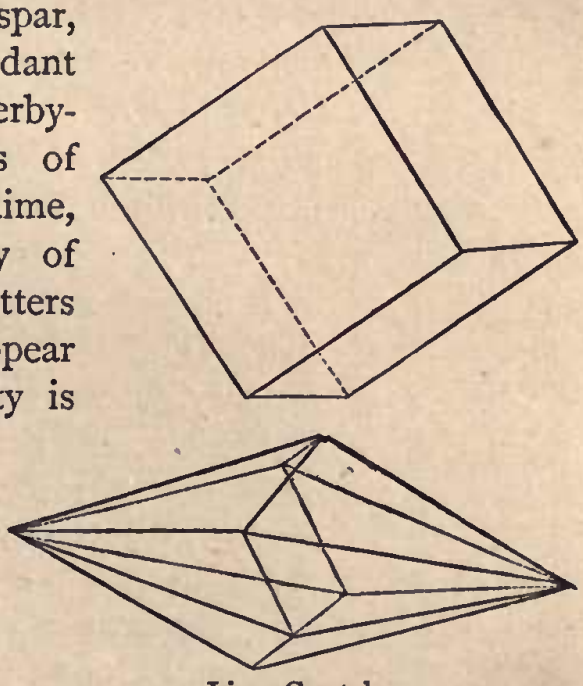


Garnet Crystal.

23. TOURMALINE occurs in nine-sided crystals, mostly broken pillars; it is black or green in colour, and has a vitreous lustre. Its specific gravity is 3 to 3·3, and its hardness 7. Fine crystals of tourmaline are found in red granite at Bovey Tracey, Devonshire, and in the mica slate and granite rocks of Pennsylvania.

The following are all aluminous gems: the *diamond*, which consists of pure carbon, the hardest and most valuable—hardness, 10; the *corundum*, or adamantine spar, the hardest substance next to the diamond—hardness, 9; the blue or true *sapphire;* the green or oriental *emerald;* the yellow or oriental *topaz;* and the yellow, blue, and colourless *beryl*—hardness, 8.

24. LIME effervesces with muriatic acid, carbonic acid gas escaping. Its crystals occur in the form of rhombs and in hexagonal pyramids, as dog's-tooth spar, the latter being especially abundant in the mountain limestone of Derbyshire. The rhomboidal crystals of calcareous spar, or carbonate of lime, possess the remarkable property of double refraction, so that the letters of a book seen through them appear to be double. Its specific gravity is 2·5, and its hardness 3. The cleavage of crystals of carbonate of lime is perfect; and they can be scratched with a knife, while quartz crystals cannot, though both are alike white or yellowish-coloured and transparent. Before the blowpipe this mineral is infusible, but glows with a bright light, forming quick lime. Lime



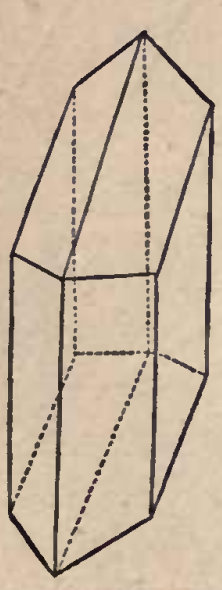
Lime Crystals.

is very widely spread over the earth's surface. In the form of chalk, limestone, and marble, it constitutes hills, and even ranges of mountains; in union with sulphuric acid, it forms sulphate of lime, or gypsum, sometimes called plaster of Paris, because very abundant near the French capital; with phosphoric acid it forms phosphate of lime, which enters largely into the composition of bone; and with carbonic acid, it forms carbonate of lime, of which all shells, both marine, freshwater, and land, almost entirely consists.

25. DOLOMITE, or magnesian limestone, is dense, compact, and of a yellowish grey colour. It forms extensive beds in the north of England, and is the material of which the Houses of Parliament at Westminster are constructed. It is found in various parts of Europe, especially in Southern Tyrol and the Dolmitic Alps.

26. FLUOR SPAR (*fluate of lime*) is a beautiful pellucid mineral of various tints and colours; it crystallises in cubes, crackles before the blowpipe, and, mixed with borax, fuses to a clear glass; it dissolves in sulphuric acid, disengaging the pungent gaseous fluoric acid which corrodes glass; its specific gravity is 3, and hardness 4. Fluor spar is found in Derbyshire in masses of an intense blue colour, which are manufactured into vases and other ornamental objects; it also occurs in Cumberland, Yorkshire, and Cornwall.

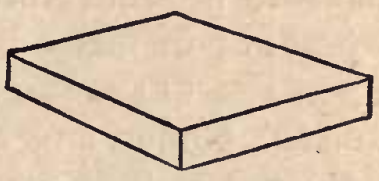
27. GYPSUM (*sulphate of lime*) when crystallised forms the mineral called *selenite;* its primitive crystal is a right prism with bevelled edges and parallelogram bases. Gypsum is also met with in nature as alabaster, and in a fibrous state, when it is sometimes called satin spar. The use of alabaster for boxes, vases, and statuary dates from very ancient times. Pliny refers to the preservation of perfumes in alabaster boxes or vases. It was from such a box that Mary of Bethany and the "sinner" anointed our Lord.[1] Compact gypsum, or alabaster, occurs extensively in the New Red Sandstone of Cheshire, Leicestershire, and Derbyshire, and is wrought into various ornamental articles.



Gypsum Crystal

[1] Luke vii. 37; John xii. 3.

28. Heavy Spar (*Baryta*) crystallises in six or eight-sided tables, and is readily distinguished by its remarkable weight and non-metallic appearance; it is either colourless, brownish yellow, red, or brown; is insoluble in acids, and melts with difficulty before the blowpipe, colouring the flame yellowish green. Heavy spar occurs along with veins of lead ore in the mines of Cornwall, Shropshire, Yorkshire, and Derbyshire.



Heavy Spar Crystal.

29. Malachite (*Carbonate of copper*) occurs in botryoidal masses (Greek, *βότρυς*, a cluster of grapes; and *εἶδος*, form) of a bright green colour, with a smooth surface, and a finely fibrous structure; it is nearly opaque, and is soluble in acids, the solution precipitating copper on the blade of a knife; before the blowpipe it crackles and becomes black, ultimately melting and giving forth copper; with borax it fuses into a deep green globule, at last affording a bead of copper. Its specific gravity is 4, and its hardness 4. Malachite is found in the copper mines of Cornwall, Cumberland, and Siberia. Australia has also recently produced blocks of malachite of great beauty, as well as fine crystallised specimens of the blue carbonate of copper.

30. Calamine (*Carbonate of zinc*) is one of the two ores usually accompanying lead, from which zinc is obtained, the other being blende. Calamine dissolves in acids with very perceptible effervescence, and melts with borax to a clear glass. It occurs in the Mendip Hills, the Peak of Derbyshire, and the Lead Hills of Scotland.

c. Metallic Minerals.

These minerals are opaque and incombustible; they usually form good crystals, and have a metallic lustre.

Metals associated with Oxygen.

Iron colours the blowpipe flame bottle-green.

31. Magnetic Iron Ore (*Loadstone*) is found in small octahedral or dodecahedral, dark, iron-grey crystals, which possess the peculiar property of attracting needles like a magnet. The ore

imparts a green colour to borax. Magnetic iron is scarce in England, but occurs at Rosedale, Dartmoor, also in Pennsylvania, and in immense beds in Norway and Sweden. This ore is not only the richest in pure metal, but it furnishes also the finest qualities.

32. SPECULAR IRON (*Iron glance*) is brilliant, hard, compact, radiated, fibrous, and distinctly crystallised, with a cherry or blood-red streak. The crystals are acute rhombohedrons. The finest specimens come from the Isle of Elba, where mines of this mineral were worked upwards of two thousand years ago.

33. RED HÆMATITE IRON ORE occurs in opaque botryoidal crystals, with radiated structure, clayey odour, colour blood-red, inclining to steel-grey, and red streak. Its specific gravity is 5. This ore is abundant in mountain limestone at Ulverstone, in Lancashire.

34. BROWN HÆMATITE IRON ORE resembles red hæmatite in its fibrous structure and the form of its crystals, but its streak is yellowish brown. Before the blowpipe it becomes magnetic, and leaves behind red oxide of iron. Its specific gravity is 4, and its hardness 5. Brown hæmatite is largely worked in the carboniferous rocks of England and South Wales.

35. BOG-IRON ORE (*Peroxide of iron*) occurs in yellowish powder containing minute botryoidal crystals. Its specific gravity is 3, and its hardness 3. Bog ore is formed from the iron contained in springs, in swamps and moors, in most parts of the world, and in lakes. It is the red scum which the little springs by the side of the road display.

MANGANESE colours borax violet.

36. MANGANESE is often found in dendritic or tree-like crystals. It is of a reddish hue, but commonly black, as an oxide, brittle, so hard as to scratch glass, and has a specific gravity of 7. Manganese is largely employed by chemists in the preparation of oxygen, for bleaching powder, and also in glass-making, to destroy the green tinge which glass would otherwise acquire. It is found in Cornwall, Devonshire, the Mendip Hills, and the Isle of Man.

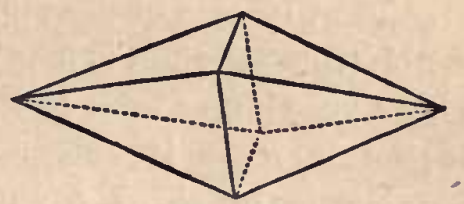
COPPER colours the blowpipe flame deep green.

37. RUBY COPPER (*Red oxide of copper*) crystallises in octahedrons

and dodecahedrons; dissolves in nitric acid to a deep blue colour, and has a specific gravity of 6, its figure of hardness being 3. Ruby copper is of great commercial value, as it contains about 70 per cent. of copper; but copper pyrites, a bisulphuret, is the principal ore, containing from 1 to 60 per cent., and next to this is the sulphuret, or grey copper, containing also a very variable percentage in the ore. Cornwall is the chief depository of this metal, but it is also found in Devon, Lancashire, Cumberland, Cheshire, Anglesey, and other parts of Wales. The ores occur either in veins or beds, and are most abundant in the vicinity of igneous rocks.

Tin.

38. Tinstone (*Oxide of tin*) occurs in square prismatic crystals, and when pure is colourless and transparent, but is much oftener brown, and even black, from the presence of oxide of iron. Its specific gravity is 6, and its hardness is almost equal to quartz, being 6 to 7, scratching glass and felspar. Tinstone is found in Cornwall and Devon, either as common ore in veins traversing the granite and slate rocks, or as stream-tin, consisting of rolled fragments intermixed with rock, sand, and pebbles. Stream-tin is separated from the gravel and sand by washing. Tin is but slightly acted upon by air or water, and is of a white, silvery colour, malleable, and easily fused. It is therefore valued as a coating for more oxidable metals, such as iron. The well-known material called tin-plate is an example of this.



Tin Crystal.

Lead.

39. Litharge (*Yellow oxide of lead*) occurs in solid masses resembling yellow jasper, and sometimes as a powder; it is also produced in the purification of silver from lead. Litharge is used in the manufacture of a yellow paint, and in various arts. *Red oxide of lead* is found in powder in veins of galena and calamine. It is used as a cheap substitute for vermilion. White lead (*Carbonate of lead*) is largely used by painters, and is abundant in the lead mines of Lanark-

shire, where some of the finest crystallisations are obtained. Sugar of lead (*Acetate of lead*) is of very great value to chemists. The most abundant of the ores of lead is *Galena* (*Sulphuret of lead*), which crystallises in perfect cubes and octahedrons. Lead mines are extensively worked in Derbyshire, Northumberland, Cumberland, Durham, Shropshire, Flintshire, Devon, and Cornwall, also in the Hartz Mountains of Germany, the United States, and Canada.

Minerals united with Sulphur.

40. Cinnabar (*Sulphuret of mercury*) furnishes the mercury of commerce, and is sometimes found in very small, complex, six-sided prisms of a fine deep carmine colour, perfectly transparent and very brilliant, sometimes in masses of a somewhat steel-grey colour, and occasionally as a fine rich scarlet powder (native vermilion) contained in the cavities of masses of the mineral. Cinnabar is readily determined by the blowpipe; when it is placed on charcoal, the sulphur burns away with a pale blue flame, giving off a sulphurous smell; and the whole of the mercury is volatilised by the heat. For this reason the mercury is obtained from cinnabar by distillation. There are extensive deposits of this mineral at Almaden, in Spain, Idria, in Austria, and in Bohemia and Westphalia.

41. Silver Glance (*Sulphuret of silver*) is one of the ores from which silver is obtained. Pure silver is found in very fine threads in some rocks, and occasionally large masses are met with in veins; but the chief supplies are the combinations of silver with the sulphurets of antimony and arsenic, which are known as the dark and light red silver ores. Argentiferous galena (*Sulphuret of lead*) also contains considerable quantities of silver. The mines of Mexico, Chili, and Peru are the most abundant sources of the precious metal; but there are also rich mines in Saxony, the Erzgebirge Mountains, Bohemia, and in Norway and Sweden.

42. Blende (*Sulphuret of zinc*), the "black jack" of the miners, is usually associated with the ores of lead; it crystallises in the form of the rhomboidal dodecahedron, is of a yellow colour when pure, but more frequently is dark reddish brown or garnet red, the darker colours arising from the presence of iron; it has a

metallic lustre, and a dark streak; it scratches carbonate of lime, and is scratched by phosphate of lime; it does not melt before the blowpipe by itself, but when heated on charcoal fumes of oxide of zinc forms a white coating upon it. Its specific gravity is 4, and its hardness 3. Blende contains from fifty to sixty per cent. of zinc, the remainder being sulphur and iron. It is found in great abundance both in beds and veins in Cornwall and several northern English counties.

43. Copper Glance is the grey copper ore of Cornish miners; its colour is dark steel grey, often running to bluish, and the streak has a metallic lustre. It melts easily before the blowpipe, but is not quickly reduced without the aid of soda. Its specific gravity is 5, and its hardness 3 to 4.

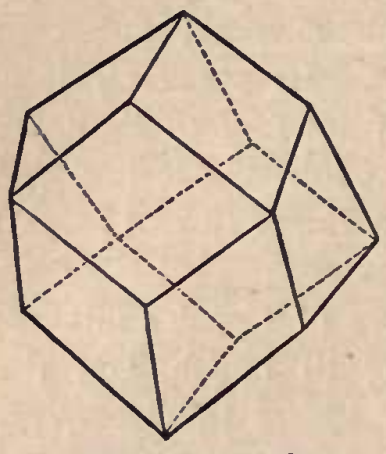
44. Copper Pyrites (*Yellow copper ore*) is the most abundant of English copper ores, and occurs chiefly in the old rocks, either in veins or beds. Its colour resembles that of brass; and it is easily scratched with a knife, differing in this respect from iron pyrites (*mundic*), which is much harder. Both this and the next variety before the blowpipe afford a globule which can be attracted by the magnet; when placed on charcoal, sulphur fumes are given off; and with borax, pure copper is yielded. Its hardness is 3 to 4, and its specific gravity 4·15. The composition of copper pyrites is, sulphur 36, copper 33, iron 31.

45. Variegated Copper Ore contains less iron and sulphur than copper pyrites, and nearly double the amount of copper. It is also softer than copper pyrites, and much redder in colour. It is often mixed with quartz and other minerals. Crystallised specimens have been found in Cornwall, where from its colour it is known as "horseflesh ore." This mineral is also found in Silesia and the Hartz Mountains of Germany.

Iron.

46. Iron Pyrites (*Sulphuret of iron*) is one of the most abundant and widely distributed of natural ores. Its colour so greatly resembles that of gold, that it is no wonder people unacquainted with mineralogy have mistaken it for that metal; for this reason,

it has been appropriately denominated *fools' gold.* Yet it is very easy to distinguish pyrites from gold; the latter being always malleable, the former never. It crystallises in cubes, octahedrons, and in forms presenting faces of the pentagonal dodecahedron. Its hardness is 5 to 6, and it has a specific gravity of 5. Iron pyrites is employed in the production of sulphuric acid, alum, and sulphate of iron, or the copperas of commerce.



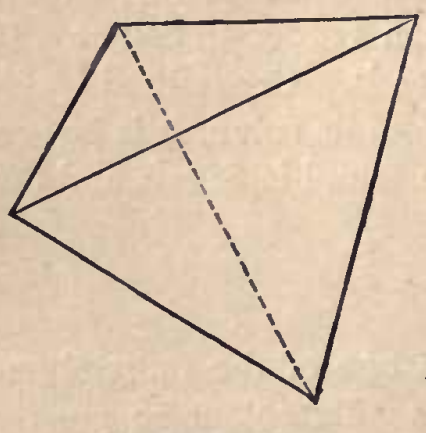
Crystal of Iron Pyrites.

47. MAGNETIC PYRITES is of a darker colour, inclining to bronze, and much softer than the former variety. It crystallises in hexagonal prisms, attracts the magnet, and dissolves in muriatic acid. Its specific gravity is 5, and its hardness 4. This ore is found in Cornwall and Derbyshire.

ANTIMONY.

48. ANTIMONY GLANCE mostly occurs in needle-formed radiately-arranged crystals; it easily yields to the pressure of a nail, and is readily fused in the flame of a candle. The surfaces of the crystals are sometimes tarnished with brilliant prismatic colours, but otherwise the colour is lead grey. Its specific gravity is 4·5, and its hardness 2.

49. GREY ANTIMONY (*Sulphuret of antimony*) supplies all the antimony of commerce. It is found either in masses or crystallised in rhombic or six-sided prisms, generally terminated by four planes; it has a shining metallic lustre; is fusible in a candle flame, and is volatilised in white fumes before the blowpipe. Antimony is not used as a simple metal; but it makes a valuable alloy, being used for this purpose in Britannia metal, type metal, etc.



Antimony Crystal.

Minerals associated with Arsenic.

50. Nickel always occurs in capillary crystals of a steel grey colour, and is generally found in small veins united with cobalt and arsenic. It is lustrous, nearly as hard as iron, malleable, ductile, and only slightly affected by air and moisture. Nickel readily fuses on charcoal, and the globule speedily darkens on exposure to the air. Its specific gravity is 8, and its hardness 5 to 6. With copper and zinc nickel forms German silver, and its alloys make excellent bases for electro-plating. It is found sparingly in the mines of Cornwall and Cumberland, also in the lead mines of Scotland, and in Westphalia, Saxony, Hungary, and Sweden. The chief ore is copper nickel, which is nearly the colour of native copper, dissolves into a light green fluid in nitric acid, and gives off arsenical fumes before the blowpipe. It occurs in meteoric iron and aërolites.

51. Cobalt Glance crystallises in white cubes, having a faint tinge of red. On being heated by the blowpipe it gives off arsenical fumes having the usual odour of garlic; it imparts an intense blue to borax or any other flux; and the resulting globule is magnetic. Its hardness is 5 to 6, and its specific gravity 6. This ore is found in many parts of Europe and in the United States. From it is prepared a fine blue colouring substance, called smalt, which is much used in potteries for painting on porcelain, for staining glass, and for giving a blue tinge to paper, muslin, calico, and other goods.

52. Copper Nickel Cobalt crystallises in cubes, is tin white to steel grey in colour, and has a strongly metallic lustre.

Pure Metals.

53. Quicksilver is the heaviest liquid with which we are acquainted, its specific gravity being 13·6. Down to —39° Fahrenheit it continues fluid, but below that depth it becomes solid. Quicksilver is used for silvering mirrors, in the construction of scientific instruments, in medicine, and as an amalgam in chemistry. Mercury is obtained from cinnabar.

54. Copper occurs native in dendroid (tree-like) crushed plates, also in cubical and octahedral crystals. It is ductile, malleable, red

in colour, and dissolves to a deep sky-blue in nitric acid. It renders the blowpipe flame green, fuses readily, and on cooling is covered with a black oxide. Its hardness is 2·5 to 3; specific gravity 8·6. Native copper is found in Western and Northern America (especially near Lake Superior), Australia, Scandinavia, and Cornwall.

55. GOLD is used in all civilised countries in many forms, especially in that of coin, the chief medium of exchange. This noble metal is unaffected by air or water; and, because of the richness of its colour and its imperishable nature, it is largely used in the manufacture of such articles of luxury as are intended to be both beautiful and durable. It has a specific gravity of 19·5, and its hardness is 2 to 3. Gold occurs in quartz veins of the older rocks in California, Australia, Peru, the Ural Mountains, and Central America; but the largest quantity is obtained from gravels and sands, into which it has been washed from auriferous rocks. It is thus obtained from the sands of African rivers, from Thibet, China, India, and Japan, and from the upper clays and pebbles of Australia and New Zealand. With the exception of iron, gold is more generally diffused through the globe than any other metal

56. PLATINUM, or PLATINA, is the heaviest metal known, its specific gravity being 21·5, rather higher than that of gold. It is of a pale, lead-grey colour, is exceedingly malleable and ductile, and is a most indestructible substance, being infusible at a heat which will melt gold. It is therefore of great use in the laboratory for crucibles. It is not affected by air, moisture, and ordinary acids. Platinum is rarely found pure, but is usually alloyed with palladium, rhodium, or some other metal. It is obtained from the gold districts of Brazil, the western slopes of the Ural Mountains, Spain, Borneo, and Ceylon.

57. SILVER is a noble metal, although less precious and weighty than gold. It is the whitest of metals, and of a brilliant lustre when polished; it is malleable, ductile, tenacious, and easily fusible, with a specific gravity of 10·5, its hardness being 2·5 to 3. The crystals belong to the cubic series, and are mostly octahedral. Silver is found in Saxony, Sweden, and South America, and largely in the lead mines, in combination with lead.

Combustible Minerals.

Carbonaceous.

58. Graphite (Greek, γράφω, I write), so called from being used in the manufacture of writing pencils, is also termed plumbago and black lead. It is not lead at all, but carbon, with a small percentage of iron; it has a metallic lustre, a fine, scaly structure, and soils the fingers when handled. Graphite is found in Canada, and in several places in the United States, and also occurs in veins and lumps in gneiss and slate rocks at Borrowdale, in Cumberland. Plumbago is very useful as a material for crucibles for the laboratory.

59. Anthracite, or non-bituminous coal, is almost pure carbon; it burns with difficulty, with a faint blue flame (carbonic oxide), intense heat, and almost without smoke, and is usually kindled with charcoal. It is found in Wales, where it is now extensively used in the preparation of iron; and it is very abundant in Pennsylvania.

60. Pit Coal burns with an abundance of smoke and flame, and differs from anthracite or stone coal in containing bitumen. Soon after this coal is placed on a fire, bitumen oozes out of it like pitch, accompanied by the escape of carburetted hydrogen gas and flame. It is chiefly employed for domestic consumption in the United Kingdom. Cannel coal, from Scotland, is the richest in volatile constituents. This variety breaks with a large conchoidal fracture, has scarcely any lustre, and burns readily with so bright a flame that thin pieces are sometimes used as candles. All coals show indications of vegetable origin, and are formed of primeval forests which have been subjected to immense pressure and chemical decomposition.

61. Brown Coal, lignite, or bitumenised coal, has a woody structure, and appears to be coal of imperfect or recent formation. It burns with a disagreeable smell, and leaves a sooty deposit. This coal is found in Central Germany and Northern Bohemia, and also occurs in a tertiary deposit near Bovey Tracy, Devon.

62. Peat is composed principally of bog moss (*Sphagnum*) and

the roots and leaves of plants. It burns with a peculiar odour, and leaves an abundant deposit of ash. Peat is found in all bogs throughout the temperate zone.

Resinous.

63. AMBER, or fossil resin, which is found in alluvial gravels on the shores of the Baltic, and on the coasts of Norfolk and Suffolk, comes from fossilized coniferous trees. It occurs in irregularly rounded pieces, from the size of a walnut to masses weighing several pounds; is transparent; of a yellow or brown colour; becomes strongly electric by friction; burns with an agreeable odour; and often encloses fossil insects. Fossil tar, petroleum, and naphtha, belong to this class of mineral fossil resins.

64. ASPHALTUM is a variety of bitumen resembling pitch, with a glossy conchoidal fracture. It burns easily with a strong sooty flame, and when pure floats on water; it is collected in this way from the Dead Sea. *Asphalte* from France and Switzerland is now extensively used for paving streets.

Sulphur.

65. SULPHUR is found native in all volcanic districts, either in masses or as an efflorescence on the soil. It occurs in yellow, brittle, acute octahedrons of a vitreous lustre, burns blue, and emits its characteristic odour. Supplies of native sulphur are obtained from Sicily, where it is a volcanic product lying in beds. But the large quantity used daily in commerce to make sulphuric acid is obtained from pyrites.

A great poet speaks of "sermons in stones;" and at the beginning of this chapter[1] we heard what the mineral kingdom has to say to us of its own beginning, and of its history through past ages. There is not a fragment of rock, or piece of metallic ore, or grain of sand, but has its tale to tell if we only knew how to listen.

And they have a *purpose*, too, as well as a history. They minister to the wants and uses of man. What would the world be without iron, or coal? The Creator prepared these, and a thousand other

[1] See pp. 135–139.

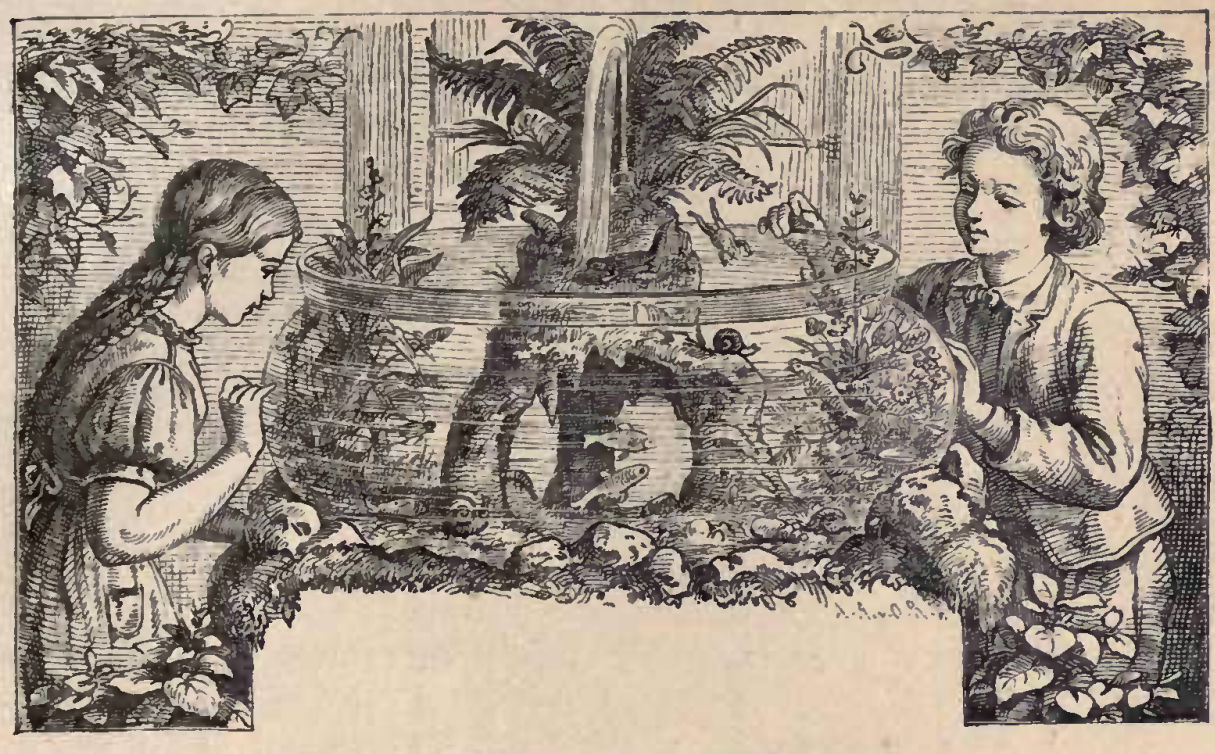
products, with gracious care, that man when created might find the earth, like a noble habitation, fitted and fully stored for his reception. These things are ours, not only to admire but to enjoy with thankfulness and wisdom.

Another proof of the Divine forethought and care is in the *distribution* of these riches. One land possesses what another lacks. And from the distribution of products throughout the globe there arises the necessity for interchange and commerce, which bring men together, make them feel an interest in each other, and thus promote "peace on earth, goodwill to men." Society has its origin in the Divine constitution of our nature, just as minerals have their origin in the Divine construction of the earth. The latter is made to serve the interests of the former. The component parts of the earth, created long before man was "formed of the dust of the ground," thus promote the welfare of man, not only in his individual, but also in his associated capacity. It is evident, then, that, according to the indications of the Divine will, the individual was not meant to be selfish, and seek his own good alone, but to think also of the good of others. For God teaches us that we are dependent one upon other, and that if we would gain the good things — the natural products—which others possess, we must also give them a portion of our good things. Hence arises commerce, which is alien from strife and war, and which promotes the peace and prosperity of all nations.

But, after all, it is of the greatest importance that, while collecting and studying the precious gems and useful minerals, so bountifully bestowed by the great Giver of all, we should seek to possess also that true wisdom which is better than silver, and the gain of which is better than fine gold, being even more precious than rubies. While searching for the treasures of the earth, the unsearchable riches of Christ should not be forgotten. As the man in the parable digged in the field for the pearl of great price, and when he had found it, sold all that he had, and bought it, so let the collector of material gems search diligently till he find the best and brightest blessings known on earth—repentance for sin, pardon through Christ, the presence of the Holy Spirit in the heart, and the everlasting love of the Father abiding on His redeemed, quickened, and grateful child.

Here, then, are the *only true and lasting riches.* It may do us good to listen to some words from a grand poem, written thousands of years ago. Will the reader know where to find it?

"Surely there is a vein for the silver,
And a place for gold where they fine it,
Iron is taken out of the earth,
And brass is molten out of the stone.
As for the earth, out of it cometh bread,
And under it is turned up as it were fire.
The stones of it are the place of sapphires,
And it hath dust of gold.
There is a path which no fowl [*i.e.* bird] knoweth,
And which the vulture's eye hath not seen;
The lion's whelps have not trodden it,
Nor the fierce lion passed by it.
He [the miner] putteth forth his hand upon the rock,
He overturneth the mountains by the roots.
He cutteth out rivers [*or* channels] among the rocks;
And his eye seeth every precious thing.
He bindeth the floods from overflowing;
And the thing that is hid bringeth he forth to light.
But where shall wisdom be found?
And where is the place of understanding?
Man knoweth not the price thereof,
Neither is it found in the land of the living.
The depth saith, it is not in me,
And the sea saith, it is not with me.
It cannot be gotten for gold,
Neither shall silver be weighed for the price thereof;
It cannot be valued with the gold of Ophir,
With the precious onyx, or the sapphire.
Whence then cometh wisdom?
And where is the place of understanding?
God understandeth the way thereof,
And He knoweth the place thereof.
For He looketh to the ends of the earth,
And seeth under the whole heaven;
And unto man He said:
Behold, THE FEAR OF THE LORD, that is wisdom,
And to DEPART FROM EVIL is understanding.'



Section VII.

THE AQUARIUM.

In many houses belonging to persons of taste and refinement, there are to be seen pretty rectangular or circular aquaria, containing water, green plants, and fish swimming gracefully to and fro. A small and economical aquarium is easily procured, and by the aid of a few plants the water may be kept pure, and the fish in a state of health. As such an aquarium is always a source of instruction and pleasure, we shall now endeavour to show how to make, stock, and preserve one.

The Principles on which Aquaria are constructed.

It is well known that water, when kept in a vessel with fish, gradually becomes impure, and requires changing; if this is not done, the fish will become unhealthy, and ultimately die. But if an aquatic plant, such as the water milfoil, or the hornwort, be taken from a fresh-water stream or pond, and placed in the vessel with the fish, the water will continue fresh and transparent, and the fish will

apparently enjoy life quite as much as if they were swimming in the waters of their native stream. This will be more especially the case if a fountain is made to spring from some rockwork placed in the midst of the aquarium, so as to keep the water in a state of continual agitation. If this is done, and the water is kept at a proper temperature, and a suitable amount of sunlight allowed, the aquarium cannot but prove a great success.



The Fountain in the Aquarium.

The reason of all these arrangements is easily explained. Oxygen is necessary to the life and health of the fish, and the plants give this off in large quantities, from the pores of their leaves, under the influence of sunlight. This is plainly proved by observing the quicksilver-like globules of pure oxygen, which appear on the leaves, gradually increase in size, and at last by their buoyancy ascend through the water, and burst on its surface. The water is thus oxygenated by the plants, whilst the carbon required for them is produced by the fish in the form of carbonic acid gas, which they exhale into the water from their gills. This gas is the chief food of plants, the carbon being retained, and the oxygen set free, to be again consumed by the fish, and breathed back once more into the water as carbonic acid. It is thus that plants keep the water in an aquarium

pure and fresh, and enable it to sustain fish or any other fresh-water animal of suitable size which may be introduced into it. The natural history and extraordinary changes which some of these animals undergo may be most conveniently and accurately studied in an aquarium.

The secret of success in an aquarium is the maintenance of the proper balance between animal and vegetable life. When this balance is preserved, it will be shown by the beautiful clearness of the water, the bright and healthy greenness of the plants, and the growth and activity of the fish and other animals with which it is stocked.

In short, we have to do, on a small scale, what the Creator has accomplished on a large one. We must, therefore, conform to the laws of nature, which are the laws of God. We cannot make new laws—no man can; we can only obey those that are in force, and maintained in force by Him who rules over all things and administers His laws. If we obey His laws, whether in the natural or the moral world, all will be well. If we disregard or disobey them, we shall surely get into trouble, and our works will come to naught. Observance of Divine laws is thus as necessary in the construction of an aquarium, as in that higher sphere where "sin is the transgression of law."

Practical Directions for Making an Aquarium.

An aquarium may be chosen of a circular shape; but as that form distorts the objects when seen through the sides, it is far better to purchase a square or rectangular glass tank, as then the animals will present their natural appearance to the observer. The bottom of the tank should be covered with a layer of clean river sand, with a piece of rock in the centre; or an arch may be constructed of angular stones cemented together, care being taken to make the top rise like an island above the surface of the water. This island should be planted with ferns and moss, to make it a suitable resting-place for lizards or similar amphibia. The sand should next be covered with a layer of clean quartz, pebbles, and shells, amongst which the aquatic plants selected should

be arranged. The water should then be gently poured down the side of the tank by means of a piece of tubing bent into the form of a siphon. The adoption of this plan prevents the disturbance of the sand, which would render the water turbid. As the water rises in the vessel, it will buoy up the plants, which will thus assume their natural position. Last of all, the animals intended to be kept, such as fish, water insects, larvæ, lizards, frogs, or a small tortoise, should be introduced, when the aquarium will be complete.

All these objects can be collected from ponds and streams with a dip-net, and may be safely brought home in a fishing-can; and specimens of the water plants found growing with the animals should always accompany them. In order to accomplish all this successfully, it may be necessary to undertake several excursions into the country; but time thus spent will afford both instruction and pleasure.

The Plants suitable for an Aquarium, and Where to find them.

The water star-grass (*Callitriche verna*, L.) is exceedingly abundant in almost every fresh-water stream, and is easily recognised by its elongated stems, linear submerged leaves, and small, bright green stellate clusters of obovate floating leaves. This plant forms an admirable shelter for innumerable aquatic insects and larvæ, and also for the young of fresh-water mollusca, as soon as they have become developed from their ova or spawn.



Water Star-Grass.

The common water-plantain (*Alisma plantago*, L.) grows in pools and rivulets running by roadsides and meadows, in early spring. This plant will readily take root and flourish in the aquarium. The eel-grass (*Vallisneria spiralis*, L.) is a submerged species, found in slowly running streams, and is very ornamental.

The brookline (*Veronica beccabunga*, L.) and water speedwell (*Veronica anagallis*, L.) are found by streams and in boggy places, and have pretty bright-blue flowers.

The water mint (*Mentha aquatica*, L.) will be easily recognised by its fragrance.

The hornwort (*Ceratophyllum demersum*, L.) grows at the bottom of fresh-water streams in such abundance, that it appears like a grove of fir trees covered with water.

The white water crowfoot (*Ranunculus aquatilis*, L.) is found floating on the surfaces of ponds and pools. It has two kinds of leaves: one, much divided and submerged; the other, kidney-shaped and floating, with three to five divisions. The flowers are white, numerous, and all more or less stalked.



Water Plantain.

The curled pondweed (*Potamageton crispa*, L.) has all its leaves submerged; whilst the floating pondweed (*Potamageton natans*, L.) has long-stalked, large elliptical or ovate leaves floating on the surface of the water.

The arrowhead (*Sagittaria sagittifolia*, L.) grows in deep streams and ponds, and will be easily recognised by its arrow-shaped leaves and white flowers.

The mare's-tail (*Hippuris vulgaris*, L.) is somewhat rarely met with; it grows in stagnant water and slow streams, has a simple



Curled Pondweed.

and erect cylindrical stem, and six to twelve linear leaves growing in circles or whorls about the stem.

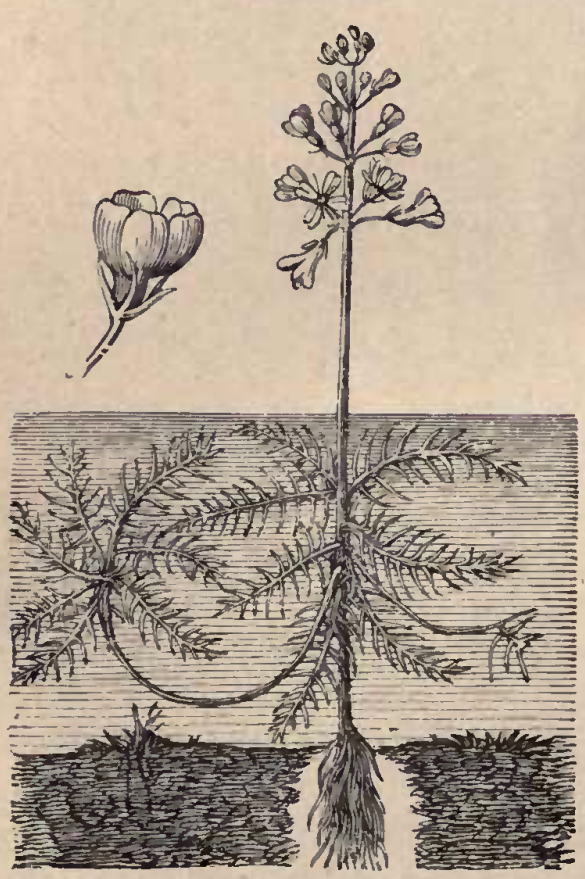
The water milfoil (*Myriophyllum verticillatum*, L.) is a very handsome plant, which grows beneath the surface of the water, and is remarkable for its pectinate (Latin, *pecten*, a comb), or tooth-like foliage.



The Water Milfoil.
a. Male. *b.* Female Flower.

The frog-bit (*Hydrocharis morsus-ranæ*, L.) is an uncommon plant, having kidney-shaped floating leaves and snow-white flowers. If the collector is able to secure the frog-bit, it will form a very valuable addition to the aquarium.

The water violet (*Hottonia palustris*, L.) has very handsome purple and yellow flowers, elevated on cylindrical stalks above the surface of the water. The leaves are pectinate, or tooth-like, and therefore very ornamental. It grows in swampy ground, and is easily propagated in the sand of the aquarium, by the stolons or suckers from its creeping roots.



The Water-Violet.

The water soldier (*Stratiotes aloides*, L.) has creeping roots, numerous rigid, spiny, aloe-like leaves, and white, delicate flowers. This plant is as rare and valuable as the frog-bit.

The *Anacharis alsinastrum*, Bab. is a native of North America, but is now so completely naturalised in England as to be found in almost all fresh-water streams. An excellent plant for the aquarium, grows freely, and requires little attention.

The white pond lily (*Nymphæa alba*, L.) and yellow pond lily (*Nymphæa lutea*, L.) can only be grown in tanks containing plenty of water. The stems should be covered as much as possible with stones, shells, and shingle, to protect them from the gold fish, or they will be greedily devoured by them.

The following plants should be grown on the island in the midst of the aquarium:

The forget-me-not (*Myosotis palustris*, L.) is commonly found in swampy ground, and will be easily distinguished from other species by its bright-blue flowers, with yellow eyes.

The round-leaved and long-leaved sundews (*Drosera rotundifolia* and *longifolia*, L.) grow on the bog moss in swamps, and may be known by the red glandular hairs on their leaves, which give out water under the warmth of the sun. The popular name of these plants arises from this curious fact.



Round-leaved Sundew.



Pennywort.

The penny-wort (*Hydrocotyle vulgaris*, L.) occurs in boggy places; it has prostrate creeping stems springing from the joints, which are stalks bearing shield-shaped leaves attached by the centre, and small, white flowers, occurring in simple umbels or clusters. The leaves resemble those of the garden nasturtium or Indian cress, but are much smaller.

Having furnished the aquarium with water plants, we now come to speak of

The Animals.

Animals suitable for the aquarium are even more abundant than plants, and all of them, with the exception of gold and silver fish, may be procured from the ponds, ditches, brooks, and rivers of the country. Those found in slowly-flowing streams or nearly stagnant water will answer best. The search for them involves only a pleasant journey into the country, with dip-net and fish-can. Nearly every plunge of the net amongst the weeds in the stream or pond you have selected will secure some object of interest for your aquarium, which can be readily conveyed home in the fish-can.

Fresh-water Mollusca.

Among the first captures effected are sure to be different varieties of fresh-water mollusca, including specimens of the very common genera, *Limnæa*, *Planorbis*, and *Paludina*. As its name implies, the shell of the *Planorbis* is quite flat and orbicular, or round, having all its coils on the same plane or level; it is easily distinguished from the shell of the pond-snail, or *Limnæa*, and from that of the marsh-snail, or *Paludina*, which are cone-shaped in outline, and have the coils or whorls somewhat elongated.

All these freshwater mollusca are very useful in the aquarium, as they are constantly at work devouring the green vegetation which clings to the plants and the glass, and which would soon spoil the beauty of the one and the transparency of the other. They are, in fact, natural scavengers, and they will do in the tank what they have done in their native stream or pond. It must be remembered that the success of an aquarium wholly depends upon the accuracy with which nature is copied; therefore, regard must always be paid to the habits of the tenants of the tank.

Fresh-water snails usually lay their spawn or ova on the leaves of plants, but sometimes in the aquarium these are deposited on the glass sides of the tank; when this is the case, the development of the young mollusca from the ova can be easily watched with the aid of a small magnifying glass.

The Fish.

At the head of this class stand the well-known gold and silver

fishes of China (*Cyprinus auratus*), which are now, however, completely naturalised in this country. These fishes belong to the carp family, in which are also included the dace, roach, chub, minnow, bream, and gudgeon. All these fishes are familiar to anglers, common in fresh waters, and very suitable for the aquarium, as they feed principally upon aquatic plants and worms. Some of them, such as the dace, roach, and chub, have bodies of a beautiful silvery hue. The gold and silver carp must be purchased, but the native varieties may be obtained from almost any river or stream by means of a suitable net. Provided the purity and freshness of the water be preserved, all these fishes will flourish in the tank.

Next in importance to the gold and silver carp, with their allies, is the three-spined stickleback (*Gasterosteus aculeatus*), which is to be found in almost every river, brook, and pond in the country. This fish is about two and a half inches in length, has large, prominent eyes, and has on its back three sharp spines, which it can elevate or depress at pleasure. It has also on the belly a somewhat triangular spine, which forms a most formidable weapon, for with this, being very pugnacious, it sometimes rips open and kills its opponent. The stickleback is the only fish at present known to naturalists which takes any care of its offspring, beyond that of depositing the ova in a suitable place, the young fry in other cases being left to shift for themselves as soon as hatched. The female stickleback deposits the spawn in a sort of nest previously made by the male fish; this nest he jealously guards, attacking all intruders with the utmost ferocity. Nor does his care cease when the young fry appear; on the contrary, he continues to keep watch over them, even carrying back any incautious straggler to the security of the nest. Sticklebacks are sometimes so plentiful in the Lincolnshire fens as to be used for manure. At Spalding, in that county, according to Pennant, a man has been known to make as much as four shillings a day by selling these fish at one halfpenny a bushel.

A young eel is an interesting object for an aquarium, and will well repay attentive observation. This snake-like animal, when at rest, buries itself in the sand at the bottom of the tank, and when in motion swims with a graceful serpentine movement.

A young pike may also be introduced into the aquarium; but it must be very small, because, when grown to a good size, this shark of the fresh waters devours all the smaller fish. For this reason, it is far better to keep it in a separate vessel, with only the fish allowed it as food for companions. Then its mode of hunting the prey may be watched, one moment apparently motionless in the water, and the next darting down upon it with great velocity. The voracity of the pike is tremendous; it not only makes sad havoc amongst the smaller fish of its native stream, but, when these are scarce, devours frogs, water-rats, field-mice, and small aquatic birds, both alive and dead, and will even contend with the otter for his victim.

The Reptiles.

This class includes four orders, viz., 1, Batrachia, as frogs, toads, and salamanders; 2, Sauria, as the lizards of cold, and the crocodiles and alligators of warm climates; 3, Ophidia, as snakes and vipers; 4, Chelonia, as land, fresh-water, and marine tortoises. Of these four orders of Reptilia, only two are available for the aquarium.

1. The Batrachian reptiles are divisible into two sections.

a. The Urodela (Greek, *οὐρά*, a tail; and *δηλός*, apparent) preserve the tail in the adult state. Tritons and salamanders are examples of this family.

b. The Anoura (Greek, *ἀν-*, without; and, *οὐρά* a tail) have the tail only in the tadpole condition, losing it in the adult state. Frogs and toads are examples of this section.

The tailed batrachians, or Urodela, are again capable of being subdivided into two well-marked groups: aquatic salamanders, or tritons, with compressed tails, and land salamanders, with round tails. The former are oviparous, that is, lay eggs; the latter are viviparous, that is, bring forth their young alive. There are two British species of aquatic salamanders or tritons.

The great water-newt (*Triton cristatus*) is very common in ponds and ditches during the summer. It passes the winter in a torpid state, concealed in a deep hole in the ground; it revives and revisits the water on the approach of the breeding season, during the months

of March and April. The triton then acquires the peculiar fin-like crest running along the back and tail, by which it is specifically distinguished. The newt is exceedingly voracious, living upon aquatic insects, tadpoles, and other small animals.



Common Water Newt.

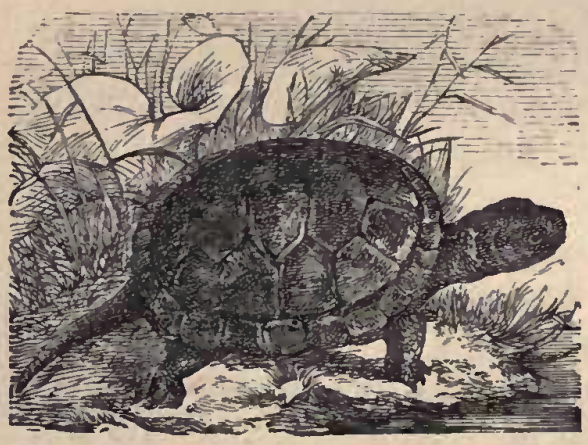
The smooth newt (*Lissotriton punctatus*) is abundant in ditches and ponds; it lives upon aquatic insects, larvæ, worms, and mollusca.

Both these species of triton are remarkable for their power of replacing lost limbs, and repairing such parts of their bodies as may have been injured or mutilated.

The terrestrial salamanders, though having the general form of lizards, have all the characteristics of batrachians. They do not live exclusively on the land, for while in the tadpole state, and also while laying their eggs, they resort to the water. They are to be found in holes, under stones, and near the roots of trees, in moist situations. They are especially active during rainy nights, when they roam abroad in search of slugs, insects, and worms.

The typical form of the Anoura, or tailless batrachians, is the common frog (*Rana temporaria*). There is hardly a pond or stream in England on the margin or in the waters of which the frog may not be found. The development of the frog from the egg to the adult state is well known, and may be easily traced. The eggs are deposited in jelly-like clusters, the small round black dots scattered throughout them being the central portions of individual eggs. The development of the tadpole commences in this spot, whence it eats its way through the gelatinous surrounding, and begins active life in the water, feeding greedily on the duckweed (*Lemna*) floating upon its surface. At first the young tadpole resembles a little fish, having a large head, and a body without members, tapering off into a long, compressed tail. In a few weeks, the hind legs make their appearance, and afterwards the fore legs; then the tail is gradually absorbed, and finally the change from tadpole to frog is completed, and the animal leaps ashore. Its food now consists of slugs and insects, of which it destroys incredible numbers. The frog is a very active and graceful inhabitant of the aquarium.

4. The Chelonia, or land and fresh-water tortoises, are slow, quiet, inoffensive animals, and feed upon vegetable substances. Their bodies are enclosed between two shields, the head, tail, and four feet being extended or retracted at will through the apertures provided for them. The upper shield, or carapace, has on its under surface the vertebræ and ribs, but these are strangely altered, the former being immoveable, and the latter widened into plates touching each other throughout their entire length. The lower shield, or plastron, shows on its upper surface that it is a peculiar modification of the sternum. The covering of these animals, therefore, is not the hardened skin, but the skeleton itself, which is situated on the outside of the body, and encloses its softer parts. The tortoise is easily obtained from



Land Tortoise.

any dealer, and it must be placed on the island, where it will contentedly remain.

Insects and Larvæ.

A great many interesting insects and larvæ can be easily taken with a dip-net from ponds and streams, and safely transferred by means of the fish-can to the aquarium, where their structure and mode of life may be advantageously studied. Some knowledge of entomology, however, is necessary to secure a judicious selection. The question to be settled is, Will they agree, or are they certain at first sight to wage a war of mutual extermination? If the collector has no knowledge of this subject, it will be found impossible to keep some of the captures in the tank for any length of time, because they are inveterate robbers and murderers of each other. The only way to keep such destructive insects and larvæ is to place them in separate jars, into each of which a water-plant should be introduced. Such a collection of small aquaria, arranged on suitable shelves, is called a water-cabinet.

The possession of such a water-cabinet, and also of a large well-stocked aquarium, containing reptilia, fish, water insects, and larvæ, amicably living together amongst beautiful aquatic plants, furnishes a source of endless amusement and instruction. Even ignorance of natural history is no reason why the attempt to collect and keep specimens in the way here described should not be made; for it is very certain that this is the way to acquire a practical, and therefore a thorough, acquaintance with animal life. Nor can such knowledge be obtained without great benefit both to body and mind.

Excursions into the country in search of natural objects are healthy and invigorating, and in order to find them some observation is necessary. After a while we shall recognise those little signs which show us that what we seek is not far off. We may then diligently follow up those signs, or patiently wait till the creature we want makes its appearance. Just as the hunter in the forest tracks the deer or the bison by the crushing of leaves on the ground, or the breaking of twigs on the bush, so by practice we may learn to observe little signs by which we may track our smaller prey. Then we shall see what

contrivances are made by them for catching and securing food, and what devices are adopted for covering their retreats, or for protection against their enemies; what wonderful instincts all creatures possess. Thus we are led to the contemplation of those Divine arrangements which constitute Providence; and then we may say with Milton:

> "These are Thy glorious works, Parent of good,
> Almighty, Thine this universal frame,
> Thus wondrous fair; Thyself how wondrous then!
> Unspeakable, who sitt'st above these heavens,
> To us invisible or dimly seen
> In these Thy lowest works; yet these declare
> Thy goodness beyond thought, and power Divine."

The following insects and larvæ can be readily procured from almost any pond or stream during spring and summer, and sometimes even late into autumn. Only a few of the most interesting examples can here be given, though all the species are deserving of notice. Specimens of aquatic Coleoptera, or water beetles, are sure to be taken in the dip-net. The following remarks are therefore made on their organisation and habits, to help the collector to an intelligent understanding of their movements. This class of insects is called Coleoptera, or sheath-wings, because the wings, when in repose, are covered or sheathed by a pair of wing cases of a horny texture. In every beetle there are three obvious divisions—the head, the thorax, and the abdomen. To the head are attached the organs of the senses—the antennæ, eyes, and organs of the mouth; to the thorax, the organs of locomotion—the wings, feet, and legs; whilst the abdomen contains the organs necessary for nutrition and reproduction.

As the beetles included in this section reside in water, their legs are flattened and compressed like oars, being peculiarly suitable for swimming—an illustration of the adaptation of means to ends seen in all God's works, and which affords evidence of His design. The body of the insect is oval or boat-shaped, and so smooth and polished in every part that it glides through the water with very little resistance; in short, it is plain that these insects are thoroughly fitted for the element in which they live. As these beetles are air-

breathers, they are obliged occasionally to rise to the surface of the water for the purpose of respiration. This is readily effected at the will of the insect, as its body is specifically lighter than water, and rises to the surface as soon as the movement of the legs ceases. When at the surface the head is turned downwards, the end of the abdomen thrust out of the water, and the wing-cases are slightly raised; the atmosphere is thus brought into contact with the spiracles or breathing-pores of the beetle. If the wing-cases are removed these spiracles can be plainly seen, by the aid of a small lens, on the upper surface of the abdomen.

The diving water-beetle (*Dytiscus marginalis*, L.) is the largest and most remarkable of British Coleoptera. These beetles are not uncommon in stagnant pools during the summer; they are generally taken in pairs, as the male and female are almost constantly together, concealed beneath the decaying foliage in the water. The dytiscus is about an inch in length, and its body is oval in outline; in the female the wing-covers are sulcate or furrowed, but in the male they are perfectly smooth. The antennæ are eleven-jointed. Two joints of the anterior tarsi, or fore-feet of the male, are dilated into cup-like discs, but these discs are absent in the female. The anterior pair of legs are prehensile, or capable of seizing prey, and the posterior pair are natatorial, or formed for swimming.



Female Water-Beetle and its Larva.

Thus equipped for its piratical life, the dytiscus becomes an object of no little interest in the pond over which it tyrannises. Ever on the watch, it lurks beneath the weeds, or creeps stealthily along, or else rushes through the water with astonishing rapidity after insects, the ova of fish, aquatic larvæ, and tadpoles, on the juices of all of which it feeds. One minute it rises to the surface to breathe, and the next dives to the bottom of the pond, carrying a fresh supply of air under its wing-covers to serve for respiration during immersion.

The larva of the dytiscus is as voracious as the imago or perfect

insect itself. It has an elongated body, tapering towards the tail, composed of a succession of scaly rings; and six strong, well-jointed legs, by means of which it runs about with considerable rapidity. At the extremity of the tail are a pair of ciliated appendages (Latin, *cilium*, an eyelash), which the creature brings to the surface of the water to obtain a supply of air for respiration. The head is attached to the body by a flexible neck, and is furnished with long curved tubular mandibles, by means of which the prey is seized, and its juices speedily extracted. After changing its skin several times, the larva creeps out of the pond, and scoops out for itself an oval cavity in the adjoining bank, and changes into a pupa, where they may be secured by the collector by digging. These larvæ have been called water tigers on account of their voracity.

If the dytiscus or its larva were allowed to remain for any length of time in the aquarium, all the smaller animals would be speedily devoured, and nearly all the stocks destroyed. Both of them must therefore be kept in separate jars belonging to the water-cabinet.

The whirligig beetle (*Gyrinus natator*, L.) has an oval body about a quarter of an inch long, with smooth, shining, bluish black elytra, or wing-covers. The antennæ are shorter than the head, which is furnished with two ærial and two aquatic eyes, so that the insect can see in both elements at the same time. The fore legs are long, slender, and adapted for seizing prey, while the middle and posterior pairs are short, broad, and much compressed, being constructed for swimming. These insects are usually seen from the first fine days of spring till late in autumn, in groups of ten or a dozen, swimming on the surface of both running and stagnant waters, especially where some projection of the bank forms a bay, and renders the surface especially tranquil; all day long they move with great sprightliness and animation, and with no apparent object but their own amusement. So slightly do they move on the water, that they make only a few transient lines upon its surface. Being very fond of society, they are seldom seen alone. One pool usually has on its surface several groups; yet these do not interfere with one another, but perform their cheerful circlings in distinct family associations. If the observer interrupt their merriment, they seem to be greatly

alarmed, and escape by suddenly diving under the water, carrying with them a supply of air for the purpose of respiration. This supply of air looks like a globule of quicksilver attached to the extremity of the abdomen. Their fears, however, do not appear to last very long; as, in a few minutes, when everything is again quiet, the merry little insects are gambolling as before, happy in the brief life which the good God has given them.

All these facts may be easily verified by transferring a few of these beetles from the pond to the aquarium. It will, however, be necessary to cover the top of the tank with a piece of glass or wire gauze, in order to prevent their escape, as they are in the habit of leaving the water for the atmosphere after sunset. Sometimes, attracted by the light of a lamp or a candle, they will fly into a room through the open window, and alight in situations where their company is not at all desirable.

These insects dive but rarely, and then only to escape imminent danger. The American species of Gyrinus is somewhat larger than the British, and when caught exhales a very fragrant odour, resembling the smell of apples; hence they are popularly known as apple-bugs. The odour given off by the British species when captured is slightly offensive. Many more aquatic Coleoptera, whose habits are as interesting as the two species already mentioned, will be found described in works on entomology.

The water-scorpion (*Nepa cinerea*) belongs to the Hydrocorisæ, or water-bug family, of the natural order of Hemiptera. It is a carnivorous, suctorial insect, of a dark, dingy appearance, and is furnished with a rostrum, or beak, adapted for piercing the skin and sucking the juices of the animals on which it feeds. For this reason, these insects require cautious handling when captured, as some of them are apt to inflict a very painful wound with their powerful beak when irritated.



Water Scorpion.

The water-scorpion is a very common British insect, and may be met with in almost every pond. It is easily recognised by its powerful fore legs, so well adapted for seizing its prey, its oval, flat, compressed body, and the two respiratory filaments at the end of its abdomen.

These filaments are attached to the extremity of the tail, where the only available stigmata, or pores, are situated. The head of this insect is small, triangular, and much narrower than the thorax. The triangular, sharp-pointed rostellum, or suctorial apparatus, is easily exposed by the aid of a pin if the body of the insect be held between the thumb and fingers. When crushed, they exale an odour exactly similar to that of the bed-bug (*Cimex lectularius*). Many of the land species, especially the Geocorisæ, which are usually found upon plants, are of a very rich red and yellow colour.

The water-boatman, or water-flea (*Notonecta glaucus*), belongs to the Hydrocorisæ family, and is therefore related to the water-scorpion family. It is very common, and will be easily recognised. The head is broad, rounded, and occupies the entire breadth of the front of the body. As the insect swims on its back, the legs are directed upwards. The fore and middle legs are prehensile and curved, while the hinder pair are natatorial, long, compressed, and ciliated, extending on both sides of the boat-shaped body like oars. By means of these powerful organs the insect rows itself about the water with great swiftness. This is a suctorial insect, and therefore the head is armed with a triangular, sharp-pointed rostrum, or beak, with which it can inflict a very severe wound when it is handled incautiously. As its body is lighter than water, the insect rises to the surface like a cork the moment it stops rowing. In hot weather these insects usually remain on the surface of the water, resting on their oars; but they are quickly aware of the approach of danger, as their eyes are so situated that they can see both above and below at the same time. By a single stroke of their paddles, which are usually stretched out at full length, they dart out of sight in a moment. The water-boatmen can fly well, although they very rarely avail themselves of this mode of locomotion. The imago, or perfect insect, differs but slightly from the larva or pupa, and is only distinguished by its larger size and the possession of wings.



Water Boatman.

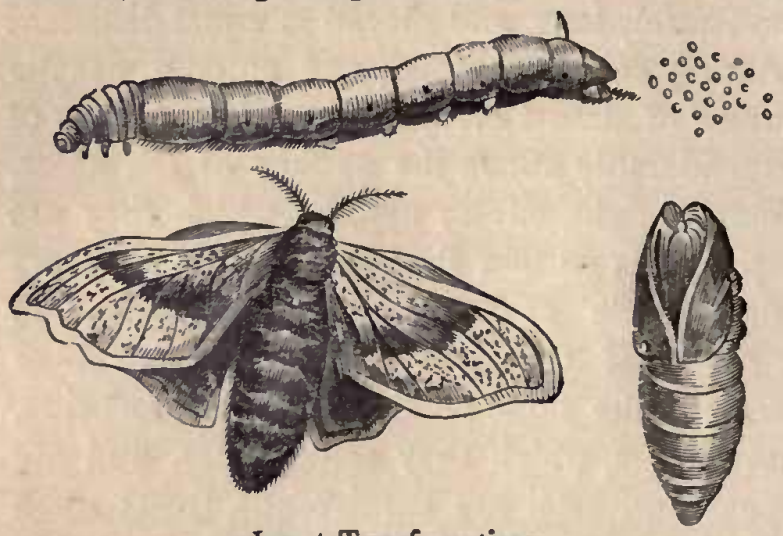
The water-measurer (*Hydrometra stagnorum*) is another interesting aquatic insect whose habits are well worth notice; it does not row

itself through the water, but skims lightly over its surface. This and the *Velia currens*, a smaller, closely-allied species, which has filiform antennæ, and the legs moderately long, and placed at equal distances apart, are to be found during spring, summer, and autumn, usually swimming against the current of almost every stream. The bodies of these insects are raised considerably above the surface of the water, and are covered with a close, bright, silvery nap, by which they are protected from the damp. It is certain that skippers, as they are popularly called, from their mode of progression, if immersed in the water, come out as dry as if they had worn an india-rubber coat. These insects belong to the same family as the Hydrocorisæ, or water-bugs. They have wings, which they seldom use, and are of a dark and dingy appearance. All are carnivorous, living upon the juices of other insects, by means of suctorial mouths. Countless numbers of insects are continually falling into every pool and stream, where their carcases may be seen floating. The Hydrocorisæ have been created to remove these offensive objects; they are the scavengers of the pools, keeping the waters pure and sweet by consuming the dead bodies which would otherwise pollute them. As soon as a fly alights on a pond or stream, it is assailed by hosts of hungry enemies, such as fish, boat-flies, and water-scorpions, either swimming, diving, or running on its surface. All these are on the look-out for such morsels, to catch and consume which is the object of all their movements. In fact, they are trying to pick up a living, like the rest of the world. It cannot be expected, therefore, that this class of insects can have a permanent place in the aquarium; the most that can be done is to give them a temporary home in the tank until some knowledge of their general habits and mode of life is acquired. As before stated, the proper place for them is the water-cabinet, where they should be kept along with the insects and larvæ upon which they feed.

Insect Transformations.

The most remarkable feature of insect life is the metamorphosis or change of form which all insects, whether they are inhabitants of land or water, undergo in passing from the egg to the imago or perfect

state. The degree of this change varies greatly in different groups of insects, but is perhaps most perfectly exemplified in the butterflies and moths. Under the impulse of an instinct which is as curious as it is remarkable, the female butterfly spends the last hours of her life in selecting an appropriate plant upon which to deposit her eggs, so that the caterpillars, as soon as hatched, shall find themselves surrounded by an abundance of nutritious food. The caterpillar was called a larva by Linnæus, from the Latin word for a mask, to indicate that it was only one of the masks or disguises that concealed the real insect. Caterpillars, after moulting or changing their skins several times, which they are obliged to do in consequence of their rapid increase of size, pass into the pupa or chrysalis state, which is one of helplessness and inactivity. Sometimes the larva suspends itself by the tail from a twig or leaf-stalk, and changes into a chrysalis (Greek, *χρυσός*, golden, referring to the bright golden spots on the surface of some of them, such as the chrysalis of the swallow-tailed butterfly, *Papilio*); in other cases it envelopes itself in a silken cocoon, or a folded leaf serves it for a covering. The aquatic larva of the diving water-beetle comes ashore, and buries itself in the bank of its native pond, and there undergoes its transformation into the pupa state, when it looks like an infant wrapped in swaddling-clothes, the Latin word *pupa*, a *baby*, well describing this condition. Out of



Insect Transformations.



Chrysalis.

the chrysalis or pupa comes forth the imago or perfect insect, which is the last stage of transformation. This perfect insect lays its eggs as its ancestors did before it, on the plant suitable for the species; and thus begins again the ever-recurring cycle of vital change. The words of the Preacher are truly applicable to these insect transformations: "The thing that hath been, it is that which shall be; and that which is done is that which shall be done: and there is no new thing under the sun. Is there anything of which it may be said, See, this is new? it hath been already of old time, which was before us."[1]

The above facts respecting insect changes are introduced here that the collector may be enabled to watch with increased attention certain common but exceedingly interesting aquatic larvæ mentioned below.

The caddis worms, or larvæ of the Phryganideæ (Greek, *φρύγανον*, a bundle of sticks), have the remarkable habit of constructing tubular portable cases out of gravel, small pieces of wood, leaves, aquatic shells, and even the pith of plants. The larva arranges the materials of the case about its body, and attaches them to itself by means of a glutinous silk, with which it lines the tube. These creatures are to be seen crawling about the bottom of almost every pond and stream during spring. The head and feet of the larva are protruded from one end of the case, but, on the slightest alarm, they are quickly drawn within it.

Larvæ cases differ very considerably, not only in their materials, but also in their mode of formation. Some are made of numerous little pieces of grass and stems of aquatic plants, cut into lengths and placed crossways, forming a rude polygonal figure; while in other instances the pieces are arranged longitudinally, or parallel with the body of the lava. But, whatever the material employed, the little builders usually contrive to make the cases of the same specific gravity as the water, so that they may be carried with ease.

When about to assume the pupa state, the creature creeps up the stem of some aquatic plant, till the mouth of its case just reaches the surface of the water. It then spins a kind of grating at both extremities of the case, and thus provides at the same time the means of

[1] Eccles. i. 9, 10.

respiration and defence. After the appointed time of torpor as a pupa, it once more becomes animated, easily tears its way through the silken grate, crawls a few inches out of the water, throws off its pupa skin, and becomes a winged insect, called by anglers a caddis fly or water-moth (*Phryganea grandis*). The perfect insect is a small brown moth, with wings thickly coated with hair, which are folded at the sides of the body during repose. These moths fly in troops above the surface of the water towards sunset. Both in the larva and imago state they are eagerly devoured by fish.

The very common larva of the dragon-fly (*Libellulidæ*) resembles the perfect insect deprived of its wings. It is most repulsive-looking, as it slowly crawls about the muddy bottom of the pond, preying on worms and insects. No one would suppose that such dingy, sluggish larvæ could change to those splendid neuropterous or nerve-winged insects, the Agrion and the Libellula—creatures whose beautiful gauze-like wings and steel-blue bodies sparkle in the sunshine with all the colours of the rainbow. They seldom leave their native pond or stream, but swiftly hunt and devour their smaller neighbours.

These are only a few of the wonders of life in the country, in the pond, and in the stream, which may be verified and studied at home by means of the aquarium.

These striking changes in the lives of insects from a lower to a higher stage of organic metamorphosis, naturally suggest the revealed truth that this life is only a state of preparation for another and a higher state of existence. Indeed, the Scriptures plainly declare that in the present life our knowledge is imperfect and limited; that now "we know in part, and we prophesy in part;" and that we understand, speak, and think as children. They also teach that we are destined for a higher state of existence beyond the grave, and that when that which is perfect is come, that which is in part shall be done away. "Now we see through a glass darkly; but then face to face: now I know in part; but then shall I know even as also I am known."

The fact that immediately after death, those who in simple faith in

[1] 1 Cor. xiii. 10–12.

Christ Jesus have followed His steps, shall enter upon a brighter and better life than this, is one of the most precious truths of Revelation. The striking illustration of this afforded by the progressive metamorphoses of insects has been well expressed by the well-known authors of the *Introduction to Entomology*, in the following lines:

"Shall the poor worm that shocks thy sight,
The humblest form in Nature's train,
Thus rise in new-born lustre bright,
And yet the emblem teach in vain?

Like thee the hapless reptile lived,
Like thee he toiled, like thee he spun;
Like thine his closing hour arrived;
His labour ceased, his web was done.

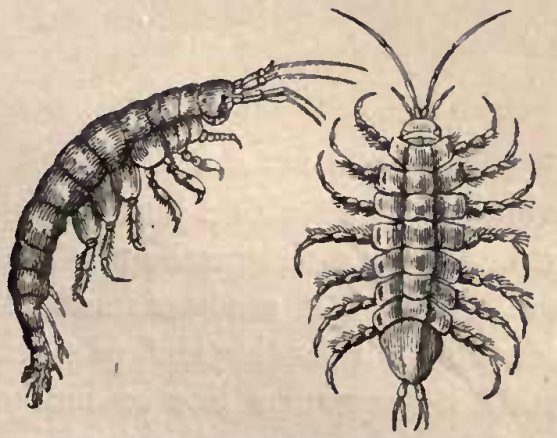
And shalt thou, numbered with the dead,
No happier state of being know?
And shall no future morrow shed
On thee a beam of brighter glow?

Is this the bound of Power Divine,
To animate an insect frame?
Or shall not He who moulded thine
Wake at His will the vital form?

Go, mortal! in thy reptile state,
Enough to know to thee is given;
Go, and the joyful truth relate,
Frail child of earth! high heir of heaven!"

Fresh-water Crustacea, Polyps, and Infusoria.

The water-flea (*Gammarus pulex aquaticus*) is a small, crustaceous insect common in fresh water; it has a bent, compressed body, and has the power of leaping and swimming with the greatest ease and activity.



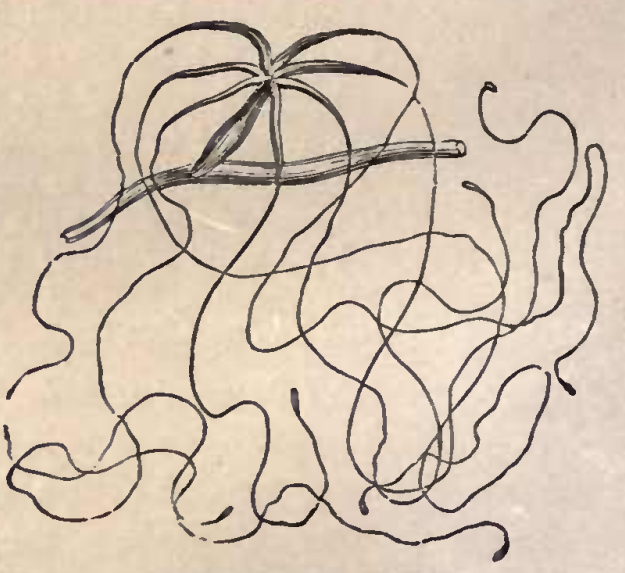
Water-Flea and Water-Woodlouse.

The water-woodlouse is another common free-swimming crustacean, which deserves a temporary home in the aquarium, where its habits may be observed with much pleasure.

There are two species of polyps, the green polype (*Hydra viridis*) and the brown polype (*Hydra fusca*), which will probably find their way into the aquarium, generally in connection with the fronds of the duckweed, the water star-grass, or an aquatic moss. The brown polype is much larger than the green variety, and will be easily recognised by its colour. Both may be procured without difficulty from almost every pool and stream during summer. It is only necessary to introduce an open-mouthed bottle amongst the surface vegetation of the pool, and to allow some of it, with a little water, to flow into the vessel. The bottle should then be set aside in a quiet place until the sediment is all settled, and its contents are free from agitation; when this is the case the captured hydras will be found adhering to the glass. They may be easily transferred to the glass slide on the stage of the microscope by means of a dipping tube, where the extreme simplicity of their organisation can be examined. Each one consists of nothing but a digestive cavity or stomach, surrounded by a fringe of long thread-like arms, or movable tentacles by means of which the animal procures its food—generally some minute insect or worm—which it seizes with a tendril-like grasp, and instantly conveys into its stomach by a contractile motion. When the hydra is hungry and in search of prey, it anchors itself to some convenient point, such as the underside of a floating leaf, or even the side of the tank itself, and extends its tentacles like so many fishing lines to a distance of not less than six or seven feet from its



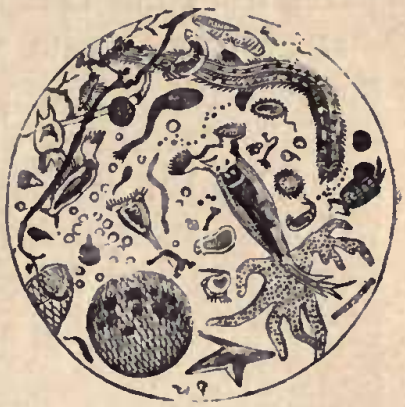
Hydras.



Hydra in search of Prey.

mouth. When the hunger of the hydra is appeased, the tentacles are withdrawn from the water, contracting into simple green tubercles about the entrance to the stomach.

Unnumbered hosts of infusoria, which are the smallest of animal forms, also establish themselves in the aquarium, and will be found upon the leaves and stems of the aquatic plants. These infusoria are, however, only visible under a good microscope.



Infusoria.

The Management of the Aquarium

If the aquarium be well supplied with suitable and healthy water-plants, and animals which live amicably together, without greatly interfering with each other's comfort, it may be considered reasonably successful, provided that the plants grow, and that the water keeps clear and free from offensive smell. Such plants as grow too luxuriantly may be cautiously cut with a pair of scissors. The fish, crustacea, or freshwater snails which may die from time to time must be removed with a hook or long spoon. This will prevent the water from becoming impure through their decomposition.

On very warm days it will be desirable to notice the temperature of the aquarium; and for this purpose a thermometer is indispensable. Small aquaria speedily become heated in hot weather; and the higher the temperature, the stronger will be the tendency to rapid decay. If the water can be kept in a state of constant motion by means of a fountain established in the aquarium, both plants and animals may be thus kept cool and healthy. Or the difficulty may be partially overcome by hanging over the sides of the tank a woollen cloth, one edge of which is dipped into the water, which will ascend by capillary attraction, and by rapid evaporation produce a very cooling effect. Copious applications of cold water through the rose of a watering-pot will freshen the aquarium and revive the plants and animals at the same time.

If, however, the plants do not grow, and the water does not

keep clear and sweet, it is better to draw off the whole of the water from the tank by means of a siphon. The animals must first be caught with a net, and transferred to water of a suitable temperature. The pebbles, shells, and rockery should then be carefully examined, when perhaps some decomposing body will be found hidden amongst them, which has caused all the mischief. But if no such discovery is made, all that can be done is to begin an entirely new collection of plants; when, with the aid of the experience already acquired, the new aquarium will be more successful.

The feeding of the inhabitants of the tank should not be too frequent or abundant. Fine hashed meat, grubs, ant eggs or larvæ are very suitable. White bread and sponge cake must be given sparingly, so that they are devoured immediately, as anything that is left in the water soon decays, and thus causes disease.

In winter, if small tanks are neglected, they are liable to fracture from the freezing of the water. Only foreign plants can be preserved during the cold season, as all our native ones either lose their green colour or die. One of the most suitable plants for keeping during winter is the *Calla æthiopica.*

The proverb "practice before theory" is especially applicable to the keeping of aquaria; and those who keep them will soon learn by experience how to regulate their temperature both in summer and winter, when to renew the water, and how to feed the animals. Time and experience will surmount every difficulty, and show how much artificial aid the aquarium really requires, and what must be left to nature, in order to produce a "pond in miniature," with its curious aquatic life and its insect transformations.

Animal life in the Aquarium.

The gold fish pursues its winding course in the aquarium with slow and measured movements, its heavy habit of body and peaceful temperament being ill-adapted for sudden turnings and hurried motion. It is only when the sand of the tank is suddenly shaken that the gold-coated Chinese carp, by a single stroke of his tail fins, plunges for a moment into deep water, or hides himself be-

hind the rockery; but the next minute he is again visible, moving through the water as deliberately as before, as if no enemy were near, and nothing had ever occurred to disturb his equanimity. Twelve o'clock appears to be the best time for feeding the gold fish. They seem to know this hour, and make their preparations accordingly, especially if a midday meal is regularly served in the house where they are kept. Well do they know why the white tablecloth is spread and the plates are laid. What bustling and fighting there is amongst them, in order to catch and tear to pieces the morsels of meat thrown into the water, before they fall to the bottom of the tank!

The aquarium and its inhabitants appear especially interesting by lamplight, the fish being then awake and active, with great staring eyes and wide-open mouths. If, when the night is warm, the gold fish almost unceasingly snap at the air as they rise to the surface, it indicates that they are suffering from inflammation of their breathing organs, and the air must be cooled for them, if possible.

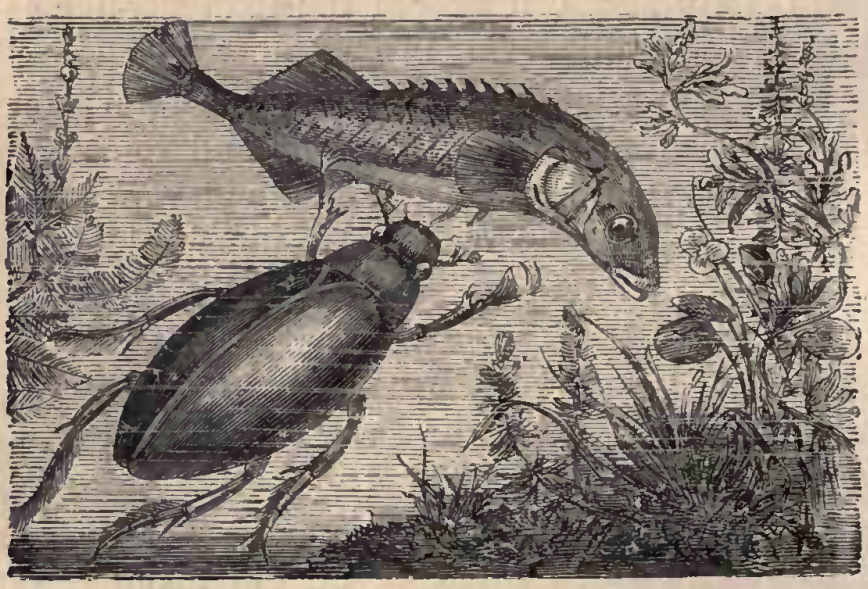
How different the life and habits of the stickleback are from those of the gold fish! Nothing can exceed the lightning-like rapidity of the motions of this battle-loving fish, whether it is moved by sport, anger, or fear. Sometimes a stickleback will swim alone near the surface of the water, active and watchful; and sometimes two or three of the fish will together examine and voraciously seize every scrap of food, dismissing such as is unpalatable with evident contempt, but never missing an opportunity of displaying their natural ferocity.

All the movements of the pond-snail will be found interesting, if they are attentively watched, although he seems to lead a dream-like life and is somewhat dull and slow. If you are fortunate enough to have a pond lily in your tank, this snail will make a pasture-ground of its foliage and flowers, or he will luxuriate on the beautiful green microscopic algæ clinging to the glass. As the pond-snail must come to the surface for the purpose of breathing, he can only live in shallow water. When on the surface, the entrance to the lungs, at the margin of the shell, becomes visible;

the animal can shut or open this orifice at pleasure. This opening is situated on the right side of the neck, and is furnished with suitable muscles for the admission of air. The ability of the snail to rise or sink either slowly or suddenly, to swim on the surface or creep over the plants at the bottom of the tank, wholly depends on the management of the air admitted within his body. If the snail be undisturbed, he will continue to breathe through the air hole for some time; but if alarmed, he will allow the air to escape, immediately close the opening, and sink like a stone to the bottom of the aquarium.

The sticklebacks must be kept by themselves, as they are so active and voracious that they will attack and devour almost anything that comes within their reach, and thus introduce nothing but confusion, terror, and discomfort into the aquarium. They may, however, be allowed a place in the water-cabinet, of which they will prove lively and amusing tenants, and then their curious habit of nest-building can be studied.

Several of the larger species of water beetles also cannot be allowed a home in the tank, as they would soon make fearful havoc among its more peaceful inhabitants. The engraving represents a large water beetle (*Hydrus piceus*), not uncommon in ditches and ponds, attacking a stickleback. Of course such animals must be kept apart, as they cannot live together without quarrelling, and the quarrel in this case is a mortal one, and will not cease until one or other of the combatants is dead. The British beetle is one of the most danger-



Large Water-Beetle attacking a Stickleback.

ous and destructive insects that can infest an aquarium. One morning we found the body of a gold fish which had been bitten to death by this beetle; and, on another occasion, during the night he killed and partially devoured a salamander. In this case, we could not be mistaken as to the culprit, as we found him sitting upon the body of his victim. We at once decided upon the expulsion of an enemy who would very soon have devoured our entire stock of animals.

The lizard tenants of the aquarium will prove pleasant objects of study. The harmless, bright-eyed, active, slender little *Lacertæ*, which have nothing whatever repulsive about them, but are adorned with the most brilliant colours, are allied to the monstrous fossil crocodiles of the antediluvian world, whose colossal bones excite our wonder and astonishment; they are closely related also to the present living crocodiles and alligators of warm climates, and for this reason we cannot help feeling interested in them. The salamander commences active life in the spring of the year, occasionally rising to the surface of the water to breathe. Having taken a good mouthful of air, it sinks quietly to the bottom of the tank, where, however, it is on the look-out for food, especially insects and worms. The engraving represents a battle between two salamanders for a common earth-worm, which is struggling on the ground between them.



Battle between two Salamanders for a Worm.

After the usually moist weather of spring has been succeeded by the warmth of summer, salamanders generally leave the water and betake themselves to the land, concealing themselves under

stones in moist, cool places. Here they have an undeniable resemblance to miniature crocodiles, having flattened heads, jaws armed with numerous teeth, elongated bodies and tails, and feet of equal length; these last are similar to those of the frog, to which animal they are more closely allied than to the crocodile. The whole race of lizards and salamanders in England and Europe are timid and inoffensive, living upon slugs, insects, and worms, and they may be handled with impunity.

If the aquarium be properly managed, these reptiles will act as they would do under natural conditions. They will leave the water as the weather gets warmer, and hide themselves among the plants of the island, and in the crevices of its rockery. Sometimes, however, they escape from the tank into the room where the aquarium is situated.

Leeches cannot be allowed in the tank, as they will be apt to fasten themselves by their suckers to the fish and other animals. Nor can the Hydrocorisæ or water-bugs be harboured in its waters, as they will puncture and prey upon their neighbours, and thus prove a source of discomfort and even destruction.

Some of the larvæ of the water beetles may be retained. These lurk at the bottom of the tank until the larva of a gnat, or something similar, comes into their neighbourhood, when the unhappy victim is seized in a moment by the powerful mandibles of its enemy, carried to the stem of an aquatic plant, and there drained of its vital juices. All these larvæ are predaceous and carnivorous, and similar scenes are enacted every summer's day on a grand scale in every pond and stream. The water-tiger, or larva of the Dytiscus or diving water-beetle, preys on the larva of the Libellula or dragon-fly; whilst the dragon-fly itself, from the moment of its birth as an imago or perfect insect, is constantly on the watch for the insects upon which it feeds; and at last it, in turn, probably falls a victim to some swallow, or other insectivorous bird, long before the light of the first day of its existence has faded from the evening sky. If such be the fate of one dragon-fly, it will not be missed; for there are innumerable sleeping chrysalids which the next day's sun will awaken and animate with the same irrepressible vitality.

These natural phenomena suggest solemn and useful lessons to the devout and thoughtful mind. What are we, or what our father's house, when we compare ourselves with God's great and wonderful works in nature? Whatever we may think of ourselves, the world at large will not miss us; and when we have played out our little part in life's drama, and the curtain falls on our history, the affairs of the world will be carried on without our aid or presence. Yet we may be sure that, notwithstanding the superabundance of life, and the infinitude of the Divine resources, and although our places can soon be supplied, our services will neither be overlooked nor forgotten. God has been mindful of us ever since we first drew breath; and we do not live in vain. How much or how little will be placed to our credit in "the books," eternity alone will determine; but there is nothing either in Scripture or nature to indicate that our lives do not each contribute in some way or other to the world's improvement and advancement, and to the fulfilment of God's final purpose in the animate creation.

When a new animal is introduced into the aquarium, it shows evident signs of not being at home in its new habitation. It disturbs the sand at the bottom of the tank, strikes violently against its sides, and gets in the way of the older tenants. But after a time it becomes familiar with its abode, forms friendships and antipathies amongst the inhabitants, and becomes one of the family. It wisely practises the lesson so hard for some human beings to learn through life—it adapts itself to circumstances. We may be sure our position in life is no accident, but is part of the kind and loving discipline of our Heavenly Father. Let us seek to do His will, whatever may be our calling in this life, calmly trusting all our affairs to the hands of Him "who spared not His own Son, but delivered Him up for us all," knowing that He will, with "Him, also freely give us all things."



Section VIII.

THE TERRARIUM.

The Study of Natural History promotes Health, Longevity, and Religion.

A WALK into the country in fine weather should always do one good. When wearied with the turmoil of city life, it is a great pleasure to turn to the woods and fields where we can see the flowers and hear the birds sing. Communion with nature is invigorating and beneficial to man. A ramble in the country is especially enjoyable, if the attention is directed to the study of natural history. Such are the riches and productiveness of nature, that there is ample employment for all her students, no matter what their taste or capacity. One is attracted by the countless diversified forms of the green plant world; and another by the active life which covers the earth's surface. Whilst the botanist looks after the plants, the zoologist goes after the animals, finding out their homes, and interesting himself in their mode of life, the rearing of their young, and their way of defending themselves against their numerous

enemies. The naturalist endeavours to obtain the animals, so as to study their habits more carefully, and thus arrive at a correct knowledge of their way of life. In this manner he learns to observe facts, and to collect and arrange the insects, birds, shells, etc., which he has acquired. All natural objects are interesting to him, so that when he is in the country he is never without occupation. Nor can such studies be rightly pursued without producing a deep and abiding conviction that not one even of the humblest of beings "is forgotten before God."[1]

Practical Difficulties in the Study of Natural History, and how to overcome them.

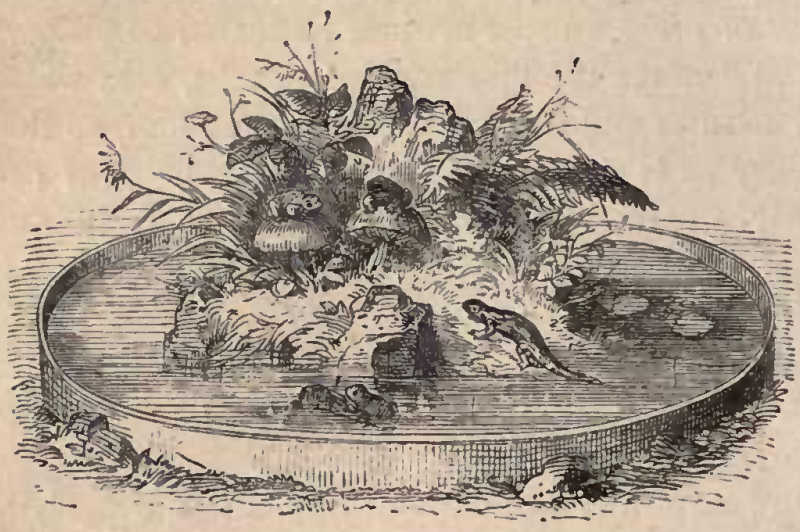
The practical study of nature is not without difficulties, especially to persons of limited income, or who are obliged to live in cities. Such persons must either take a long, weary walk through the city, or go some distance by rail before they can find a field for their research. This involves both time and exertion, and perhaps expense. It is therefore desirable, if possible, to bring the country into the city, and to form a collection of natural objects in the library or drawing-room, or other convenient place at home. Flowers are cultivated in windows, adding greatly to the beauty of the rooms, and songsters of the woods are confined in cages, adding to their cheerfulness; and with a very little additional expense may be arranged a *terrarium* (Latin, *terra*, the earth or land), in which a number of small animals, such as frogs, lizards, and snakes, may live together. The natural history of these animals can thus be carefully studied, and all the stages and changes of their life observed.

Instructions for the Formation of a Terrarium.

First, as to the enclosure or cage. If it is intended to preserve only small animals, such as lizards, a box will be sufficient; it must be provided with air holes, and a sloping glass roof. The soil within this enclosure should be about one inch in depth, and covered with sand, on this should be placed a layer of moss. The imprisoned

[1] Luke xii. 6.

animals should also have a shallow vessel containing water, where they can drink, and in which they can bathe. The water (rain-water, if procurable) must be changed daily. This is the only way to preserve animals alive through the winter. The water may be kept in a large, shallow, circular, zinc vessel. In this reservoir a small island of stone may be built, and prettily planted with ferns, grasses, and flowers, as shown in the illustration.



A Terrarium.

In this terrarium there should be placed a tree for the use of snakes, lizards, leaf-frogs, and other small reptiles. This may be a dead knotted stem, planted in a flower-pot or nailed to a board. The house is now ready, and it only remains to speak of its inhabitants. It is better at first not to confine too many animals together, but rather to restrict the tenants to one or two species, to which we can attend, and which will live together in peace and harmony. As in nature different species are found in various localities, some in damp, green, shady woods, and others in dry, sunny, rocky places, similar variety of accommodation must be provided for the animals it is intended to keep. Some regard must also be paid to the dispositions of the animals, whether they will be friendly or antagonistic to one another. If snakes are to be preserved, they must of necessity be supplied with frogs and lizards to serve them as food. These



Tree for Terrarium.

animals, therefore, cannot possibly live long together, any more than small fish, such as carp and dace, can live in an aquarium with a pike. Hence it will be easily understood that a terrarium should imitate the relations of nature. It can only do this within certain limits, and will only become instructive when its imitative and circumscribed character is borne in mind.

The Animals suitable for a Terrarium, and how to manage them.

The animals most suitable for a terrarium are reptiles and amphibia, the latter inhabiting both land and water; for example, frogs and toads. In the earlier stages of their life these animals are wholly aquatic, having a fish-like appearance, and are called tadpoles. In a few weeks the hind legs can be seen, and afterwards the fore legs; this is the permanent form of the lizards and fresh-water newts or tritons—creatures which are lower in organisation than frogs and toads. In the case of these latter, development is carried further, the tail gradually becoming less, and at last disappearing altogether, when the metamorphosis of the tadpole to the frog is completed.

Harmless Reptilia.

British toads, frogs, and land and aquatic salamanders, are all harmless and inoffensive, living upon insects and worms; although they are frequently regarded with little favour, and even considered dangerous. The snake especially is associated with everything that is treacherous, unpleasant, and poisonous; yet it is certain that all the British snakes are harmless. Therefore they are desirable tenants of the terrarium, and the practical study of the different phases of their life will prove in the highest degree interesting.

The spotted earth salamander (*Salamandra maculosa*) is found all over Europe under stones in moist situations. This salamander inhabits the water only during the tadpole state, and is distinguished by its rounded tail. In this respect it differs from the aquatic salamanders or tritons, whose tails are compressed, in order to aid them in swimming. This reptile is popularly called the fire salamander, from the unfounded belief that if it is put on a fire it will immediately discharge sufficient water to put the fire out. Many of

these unfortunate animals have undoubtedly been cruelly put to death in consequence of this stupid superstition. This salamander has also been regarded as in the highest degree poisonous, its mere presence contaminating the water in which it was found. But in reality it is quite harmless, feeding on insects, snails, and worms. It can be safely introduced into the terrarium, where it will conceal itself under the stones, and pass the winter in a torpid state, without at all disturbing the other inmates. There should always be plenty of moisture, that its life may be preserved. On the arrival of spring it will again assume its wonted activity. It is about six or eight inches in length, of a blackish colour, with large, irregular, rounded, bright yellow spots.



Spotted Earth Salamander.

The toad (*Bufo vulgaris*) is another suitable tenant for the terrarium. These well-known animals somewhat resemble frogs, but are easily distinguished from them by their thick, squat, swollen body, which is covered with warts and tubercles. The hind legs are only a little longer than the fore legs, and the toad is therefore incapable of taking springing leaps like the frog. The toad has greatly suffered from a false charge of being venomous; and yet in reality no creature is more harmless, or, indeed, more useful, for it feeds upon every kind of injurious insect, larva, and worm. The common earth toad is from three to four and a half inches in length by two and a half inches in breadth. The upper side is reddish-grey or blackish-brown, with indistinct dark spots; below it is a clear grey, and the female has dark spots. The eyes are orange yellow. The toad is found in Northern Europe, Central Asia, and Japan,

frequenting woods and fields, bushes and gardens, in all possible hiding-places, in holes in old walls, in decayed trees, and in holes in moist, shady places which these animals dig for themselves. For the convenience of the toads, an empty flower-pot, with a piece cut out of its edge, should be inverted on the ground of the terrarium, to serve as their home.

Toads are nocturnal in their habits, going out to hunt in the evening, and remaining quietly in their holes during the day. When watching for its prey, the toad remains motionless, with its great, staring, prominent eyes fixed intently upon its victim; when the insect moves, the tongue is darted out with lightning-like rapidity, the insect adheres to the viscous exudation on its surface and is instantly drawn into the mouth. Toads will feed on snails, worms, spiders, caterpillars, beetles, bees, and wasps, when they come into their neighbourhood, but butterflies are too dry for them, because of the hair on their bodies and the powder on their wings. Toads will not eat dead bodies, and they can fast for a week or more without inconvenience. It will be seen from these facts that toads lead harmless and very useful lives, and that they richly deserve protection and kind treatment, as they clear gardens and grounds of so many injurious insects.

Toads, like frogs, at spawning time resort to the water; for they produce an immense number of eggs, which are not enclosed in a gelatinous mass, like those of frogs, but form long strings. Toads become very tame, and will take insects from the hand, and appear at the call of their master or mistress to receive their food, and readily distinguish them from strangers. They are far from being the horrible poisonous creatures of popular prejudice, and frequently become great pets, often reaching a great age when carefully and kindly treated. Pennant had a toad in captivity for thirty-six years, and it was only an unfortunate accident which then deprived it of life.

The natter-jack or cross-toad (*Bufo calamita*) is the only other species of toad found in this country; it has almost as extensive a geographical distribution as the common toad. Its upper side is yellowish green, with a clear yellow streak down the centre of

the back; below, it is whitish grey, with dark spots on its legs and belly. It has reddish warts and greenish-grey eyes. It dwells in holes in old walls, being greatly aided in climbing by its toes and its warty, adhesive belly. When pursued, the cross-toad draws itself together, so that the glands of its skin empty themselves, and its body becomes covered with a whitish moisture, giving out an intolerable stench, which has been aptly compared to the smell of an old tobacco pipe; this is undoubtedly a means of defence with which the animal has been provided by the Creator.



The Cross-Toad.

The proper place for keeping ordinary frogs for any length of time is the aquarium. The only frogs available for the terrarium are the tree frogs (*Hyla arborea*), which, although spawning in the water, are land frogs, and are by no means attached to moist places. There are many very beautifully coloured frogs in foreign countries; but we must restrict our remarks to the British tree or leaf frogs. On the upper side the animal is as green as the leaf on which it sits watching for insects; the under side is yellowish or pale reddish. A yellow, black-bordered line extends from the eyes to the extremities of the toes, which are widened into adhesive cushions, enabling the animal to attach itself indiscriminately either to the upper or the under surface of leaves or branches of trees. In confinement the



Leaf Frog on Ladder.

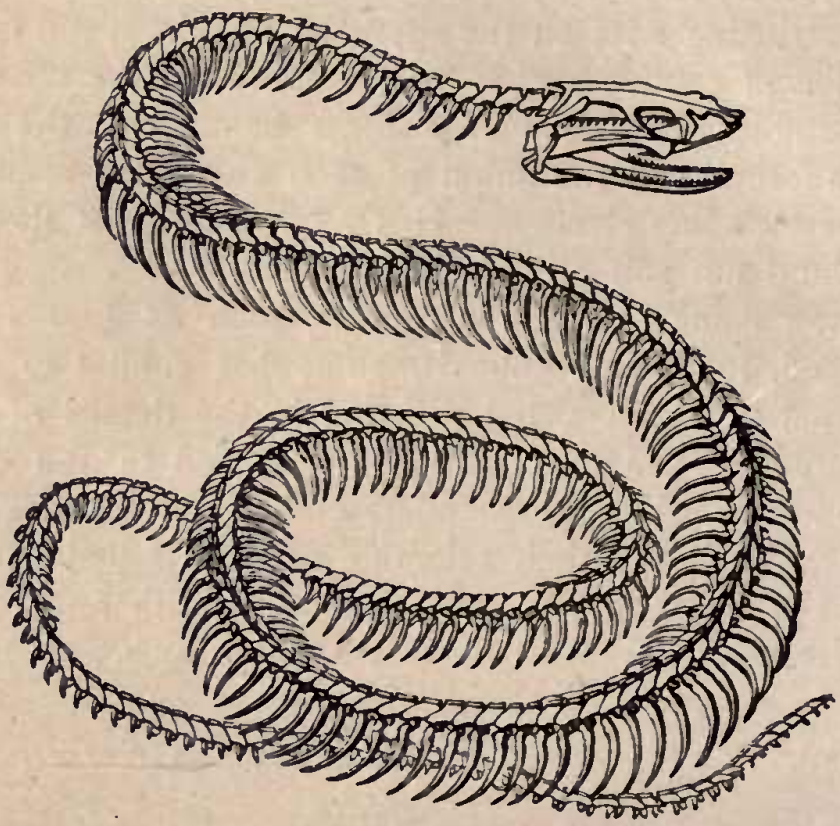
leaf frog will fasten itself on the perpendicular walls of the ladder provided for it; and, in addition to contributing to the amusement of observers by its activity as a fly-catcher, and, if a male, by uttering his clear ringing note on the approach of rain, it will form an item in the diet of captive snakes. In the Brazils, the note of the leaf frog resembles the stroke of a forge hammer or the blow of an axe in a forest, and the union of such discordant sounds produces a most astounding clamour. It is very certain that these noisy leaf frogs would not suit an orderly aquarium.

We now come to the true reptiles, such as lizards; these are four-legged, long-tailed animals, somewhat similar to salamanders in external appearance, but differing in the details of their anatomical structure. Lizards are closely allied to the crocodiles of warm climates, whilst salamanders and tritons are near neighbours of toads and frogs; their scientific name is tailed batrachian reptiles. The skins of lizards are clothed with fine coats of mail, which are absent from salamanders and tritons.

Transitional forms between Lizards and Snakes, or true Reptiles.

The footless slow-worm (*Anguis fragilis*) is a British species; although so snake-like in appearance, it is classed with lizards on account of its having a true sternum, or breast-bone—which is wholly absent from snakes—and the growing together of both branches of the under jaw. This reptile, known throughout Europe as the blind-worm, or the slow-worm, is about fifteen inches in length; it is vulgarly regarded as an adder, and because its tail breaks easily when seized it is called brittle snake (*Anguis fragilis*). It is commonly regarded as a most poisonous reptile, and is treated no better than the toad, although it is perfectly harmless, living for the most part under dry stones, and feeding on insects and worms. Sometimes foolish gardeners, seeing the slow-worm creeping over his cabbage bed, will furiously chop it into small pieces with his spade, and noticing the long-continued convulsions of the dissevered parts, say that it is impossible to kill the adder. This is sheer nonsense, and

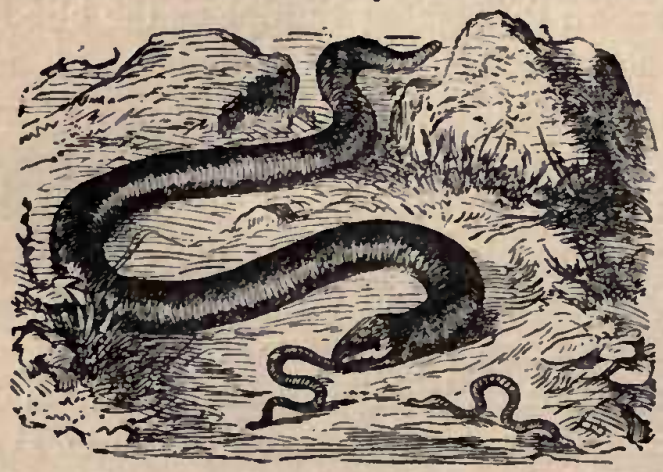
is caused by ignorance of the facts of natural history. Frequently, when field labourers have seen a naturalist fearlessly lifting a blind-



Skeleton of Snake.

worm from the ground, they have remarked on the danger to which the naturalist exposed himself in touching such a poisonous reptile.

The snake-like body of the blind-worm is generally smooth, copper brown, and of a blackish colour on the under side. The young animals have black stripes on the back, which they lose as they become older. These lizards are not blind, and they have eyelids, which are not found in snakes, neither are they poisonous. They cannot bite because of the narrowness of their mouths,



Blind-worm swallowing an Earth-worm.

and their tongue is entirely harmless. Therefore, notwithstanding the great outcry raised against the blind-worm, it is most cordially recommended as a tenant for the terrarium, where it may be easily preserved.

The common lizard (*Lacerta agilis*) is found in nearly all parts of Europe. It is an active animal, about seven inches in length, green-grey with blackish-brown band, and white spots on the upper side, and whitish or greenish, generally very changeable in colour, on the under side.

The green lizard (*Lacerta viridis*) is about fourteen inches long. The largest European lizard, which is found in South Germany, France, and Spain, is the wall lizard (*Lacerta muralis*), and is of a dark, speckled colour. The pearl lizard (*Lacerta ocellata*) is of a beautiful green colour, with bluish spots on the sides. All these species are called necklace lizards, because they have rings of great scales around their necks. They are all harmless, useful creatures,



Common Lizard and Spider.

extirpating great numbers of insects and earth-worms. They climb rocks and walls with great dexterity in their search after prey; but they are very timid, fleeing quickly at the approach of man. It is not easy to capture them, especially as the colours greatly aid their concealment. Young lizards, however, can be cheaply bought from dealers. When well treated in confinement, they will gradually

become so tame that they can be taken in the hand and caressed. They are agreeable to the touch, and will freely take the flies and worms offered to them. They must be kept well supplied with water, as they frequently drink and bathe, in this particular differing from the blind-worm.

Snakes, or true Reptiles.

Snakes are entirely destitute of limbs and eyelids, and have dilatable mouths. There is much needless fear about snakes, as only one of the species found in England is poisonous; this is the cross-adder, or European viper, which is only occasionally seen. It is necessary, however, to learn to distinguish this species from the other.

The common viper (*Pelias Berus*) has hollow teeth or fangs in the upper jaw, through which it ejects the secreted poison into the wound at the moment of biting, thus making the bite dangerous and sometimes deadly. The viper is distinguished from other snakes by a dark brown, zig-zag band, extending along the back. It is seldom above two feet long, whilst our other native snakes attain much greater length. The common viper, when free, is rather partial to mice, but when in confinement it will not touch them. These dangerous snakes must be kept by themselves, or they will soon devour all the lizards, leaf-frogs, salamanders, and toads in the terrarium. They may be separated by a wall of trellis work from the other part of the collection.



Mouth of Viper.

The harmless ring-snake (*Tropidonotus natrix*) and the smooth snake (*Coronella levis*) will agree well together in the terrarium. The smooth snake, although it will bite in defending itself, is harmless. The smooth snake grows to a length of two to three feet, and the ring-snake from four to five feet. They are easily distinguished from one another by their colour. The upper side of the smooth snake is brown or reddish grey, verging into green, with two rows of dark brown spots along the back, which are sometimes

in pairs; it has a blackish brown horseshoe spot on the neck, which often extends for some distance behind; the side is steel-blue or whitish, and is frequently spotted. The upper side of the ring-snake is grey-blue, sometimes almost black, with a double row of black spots, the belly being black, with black-bordered crescent-



Viper and Smooth Snake.

shaped side spots, which, in the female, are white, and in the male yellow. These remarkable spots originated the fable that the ring-snake wears a coronet. Another notion concerning this snake is not less foolish and false, viz., that it enters cattle-pens for the purpose of sucking milk from the cows, whereas it is rare for even a hungry ring-snake to drink milk.

Snakes cast their skins four or five times every year during the warm season. They separate themselves first from the skin of the head at the margin of the jaws, and raise the covering over the upper part of the head. A snake in this condition is called a king snake, and when ignorant persons find one in the woods, they consider themselves lucky. The upper skin of the head having been thus separated, the snake creeps out of the old skin, leaving it lying on the ground like an old glove turned inside out. These so-called snake shirts may be occasionally found in the woods in a very perfect condition, including even the covering of the eyes, which proves that snakes become blind before changing their skin.

Lizards and blind-worms also cast their skins, but they do not leave them in so perfect a condition as snakes. Blind-worms, for instance, do not pull off their shirt without tearing it at the feet. In moving, the body of a blind-worm creeps forward with easy lateral curvings, and is sometimes slowly drawn together and then stretched at full length. The snake not only curves and stretches itself, but rises up and down, winding in every direction, and is always on the look-out for its prey with quivering tongue.

Both ring-snakes and smooth snakes devour only living animals, the former eating swallows, and especially relishing frogs. The death-struggle of the frog produces a disagreeable impression on the



Ring-Snake swallowing a Frog.

observer; but it is a necessity of the nature of snakes to swallow their prey without first killing them. The smooth snakes prefer lizards, a fact of which the latter are well aware. As soon as they are placed with a snake, they run around it as if deprived of sense, gasping anxiously. They make a spirited defence, however, and this sometimes delays their descent down the throat of their foe for hours. It is indeed wonderful that snakes, which have such small heads and mouths, can swallow large animals like fat frogs, toads, or lizards. But the operation of swallowing, which is somewhat slow, and apparently difficult, is greatly aided by the structure of the snake's skull, the bones of which are separable from one another.

The operation of swallowing is not so easy for the blind-worm, because, like other lizards, this reptile has both its under jaws firmly united by osseous tissue, while snakes have the under jaws bound together only by ligamentous tissue, so that they can be stretched apart, and the opening of the mouth thus very much enlarged. Snakes drink but very little, as they usually live in dry localities. Yet, when standing on the banks of a quiet stream, the slender body of a snake may sometimes be seen gracefully gliding through the water, with head elevated and tongue protruded.

Of course, swimming cannot be accomplished in the terrarium; but snakes become tame, and are then easily handled, and can be placed in a tub, where their graceful movements in the water can be observed. It has been found that ring-snakes can swim some distance out to sea. They not only take to the water from pleasure, but also in order to pursue frogs, tadpoles, and fish, such as carp, trout, and even voracious pike. There, in turn, their fatal enemy the stork seizes them, being only too glad to devour such pleasant morsels as snakes. The flesh of a snake is not unpleasant, and, strange as it may seem, many people eat ring-snakes, and consider them as great a delicacy as eels.

Whilst the amphibia spawn in the water, snakes and land lizards lay their eggs on the ground. The ring-snake will lay its eggs in the terrarium. They are covered with a leather-like white shell, adhering together like a string of pearls; they are about the size of pigeons' eggs, and only require warmth and moisture to hatch them. If they are allowed to remain uncared for in the terrarium, they will very soon become rotten. They should, therefore, be immediately placed in a box containing a bed of manure about eight inches thick, covered with a thin layer of earth, having on the top of this about five inches of leaf mould, with some moss carefully spread over its surface. This will approximate very closely to the natural conditions under which the eggs of snakes are hatched. In August, a ring-snake will lay not fewer than fifty eggs in about ten hours. In about three weeks, little snakes about six to eight inches in length appear. The small trouble expended in the preparation of the nest will then be richly repaid.

During the first year the ring-snake grows scarcely an inch; hence the age of a snake may be inferred from its length. The artificial breeding of snakes saves much time and expense, either in the search for wild ones, or in the purchase of them from dealers.

The smooth snake lays about a dozen eggs at a time, which are hatched immediately. It is the same with the viper and the blind-worm, and sometimes even with the ring-snake.

It now remains only to speak of the winter quarters which should be provided for the inhabitants of the terrarium. In late autumn, when the leaves fall and the whole plant world is in a state of rest, the animals which depend upon plants for food, and cannot remove to other climates, like migratory birds, disappear. Hosts of insects and snails either die, or else retire into sheltered places to enjoy their winter sleep until the return of spring awakes them to renewed activity.

The snake no longer finds its prey, and therefore creeps beneath the frost-bound earth, curling itself up in its snug corner in long-continued sleep till flies and earthworms are once more to be found. In the terrarium, however, they may be kept in a state of activity all the winter, if their food is provided for them in flower-pots, which must be kept cool, and covered with layers of moss and hay.

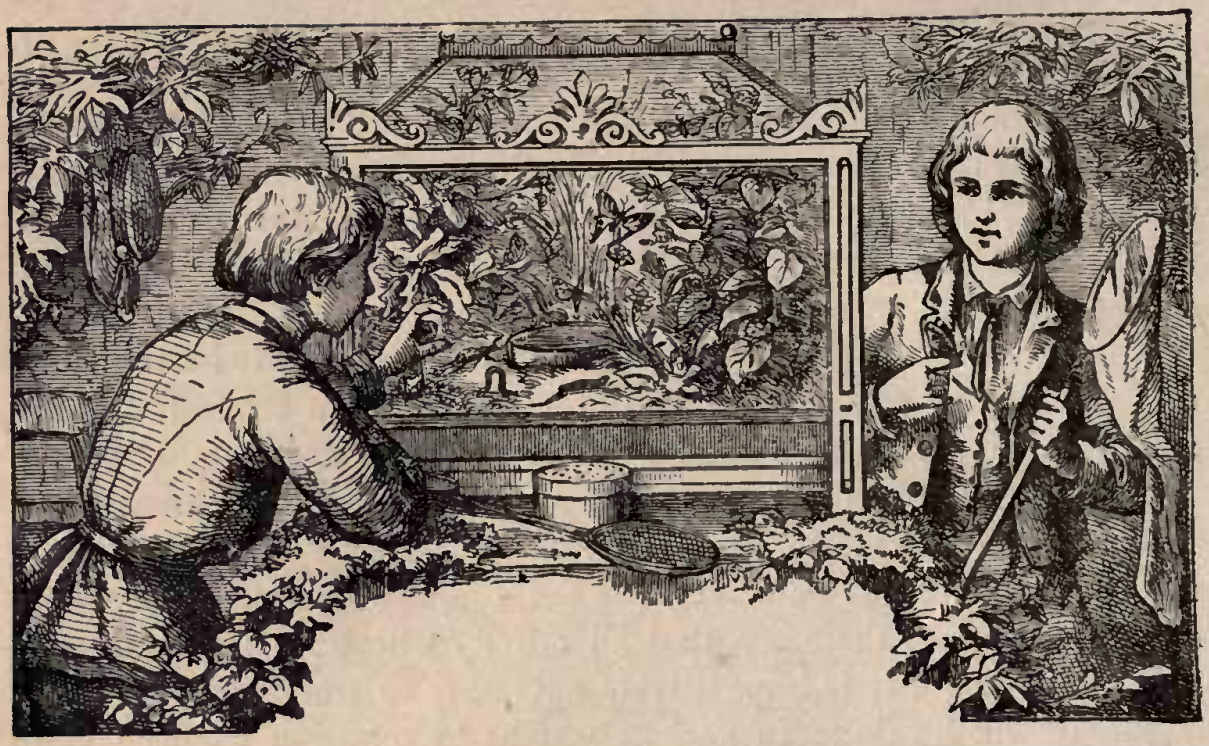
It is also necessary to keep up the supply of water in the terrarium, because it is almost the only means of preserving the frogs and lizards through the winter; for they are by no means so easily preserved in confinement as they are out of doors. When the sun shines on the terrarium, the reptiles will come out to enjoy the pleasant warmth, and will then partake of any nourishment which may be offered them. The smaller animals, however, are best left entirely undisturbed in their torpid condition. Snakes may also be preserved through the winter by covering the ground of the terrarium with leaf-mould and moss, and then placing it out in the snow, or it may be sunk into a hot-bed of manure.

Our artist has given us a picture of a terrarium, only requiring for its construction a combination of taste, a knowledge of the habits of animals, and of the natural conditions necessary to their health and comfort.

It is to be hoped that this brief account of the history of animals far below us in creation, yet which are the work of the Infinite Being, who has made us and all things both visible and invisible, may induce some readers to endeavour to form such miniature zoological gardens in their own homes.

It is also to be hoped that these creatures will cease to be regarded with repugnance and treated with cruelty. Many a stone has been hurled at an inoffensive toad or lizard, which was happily living under the care of the Maker of us all. Too little regard has been shown to the welfare of inferior beings, because we have forgotten that they, as well as ourselves, are the subjects of God's unceasing care. We hope, therefore, that all cruelty will be earnestly reprobated, and where it is imperatively necessary to put any creature to death, it will be done in such a way as to occasion as little pain as possible.





Section IX.

THE INSECTARIUM.

Origin of the Insectarium.

"ONE calm, sunny morning," says a German naturalist, "as I slowly ascended the steep, beaten pathway of a mountain slope, the numerous wild flowers which grew between the stones excited my admiration. Amongst them were the fine red grass pink, and the yellow and white wall-pepper, with its thick leaves (*sedum*), the great willow herb, with its violet flowers, the stiff-haired viper's bugloss (*Echium vulgare*), with its one-sided spikes of beautiful blue tubular flowers, erect faded thistles, and dwarf birches. But more beautiful than the intermingled flowers was the variety of butterflies which fluttered from plant to plant on the sunny slope, displaying their beautifully-coloured wings after short intervals of rest. The number of them gathered in busy motion, on a small space, was very remarkable. I saw there the peacock butterfly (*Vanessa Io*), with blue eye-spots on its reddish-brown upper wings, and red, yellow,

black, and white spots on their under surfaces; the painted-lady butterfly (*Cynthia cardui*), basking on the birch bushes; the blackish-brown mourning-cloak butterfly (*Vanessa antiopa*), its rows of blue spots with yellow white margins charmingly displayed; the silver fritillary (*Argynnis Paphia*), with red, yellow, and black spots, and elegant silvery spots on the under surfaces of the wings; the small blue hairstreak (*Thecla*); the swallow-tailed *Papilio machaon*; and even at an elevation of twelve hundred feet above the level of the sea there was the magnificent Apollo butterfly, with carmine red and black spots on its large white wings. Buzzing and swarming amidst this variegated life were bees and flies, with leaping and flying grasshoppers displaying their red under-wings. Looking admiringly on all around, I felt as if I were involuntarily taken back to boyhood's years, when I hunted these insects, and mounted and prepared them for my cabinet. I thought, would it be possible to take away with me this small paradise?

"While in this meditative mood I was startled by a multitude of noisy, happy children, who came out of the adjoining wood and stood directly before me. One active little maiden showed me a caterpillar she had found on the ground, and asked me how she should treat the nursling. I gladly directed their attention to the food-plant, and also described my early efforts as an entomologist. The issue was that I promised to show them how to preserve it and other little creatures. At that time I had only the space of a double window in which to arrange the collection. Thither I brought in boxes the food-plants with the caterpillars upon them, and began to consider how to preserve them."

For fish, salamanders, snails, and crabs, we have *aquaria;* for snakes, lizards, leaf-frogs, and toads, *terraria* or *vivaria;* so for the flying, hopping, running, humming, buzzing, chirping hosts of the variegated insect world, why should we not have *insectaria,* or enclosed spaces representing nature in miniature, where different insects might live under the same roof in associations of a peaceful and friendly character?

There is already a precedent for this contrivance. Butterfly col-

lectors have carried on butterfly breeding in boxes and chests; and we sometimes see in windows the small pasteboard houses in which children enclose grasshoppers, with pieces of cut fruit and leaves for food, so as to keep them alive for some time, in order that they may enjoy the music made by this hopping association. Naturalists, also, wishing to watch the proceedings of such social insects as bees and wasps, put them in glass cases in order to observe them more easily. Now, the insectarium is the same in principle as these case arrangements. Why not extend them? It has been done. Mr. Macpherson has sketched a plan of a repository or home for insects, which he was the first to call an "Insectarium."

How an Insectarium should be Constructed and Regulated.

An insect prison should fulfil three conditions. It must, first of all, be well supplied with those plants upon which the confined insects feed, in a healthy, vigorous state. It must, second, admit a proper amount of light, which is indispensable to their vital activity. Thirdly, and lastly, it must be well-ventilated, for the insects must have not only plenty to eat, but an abundance of fresh air, or free breathing space.



We give a picture of such a well-arranged insectarium.

It consists of a wide box, the walls being formed of plate-glass, in order to give free access to the sunlight and to show the interior as much as possible. The roof is formed of trellis-work or wire gauze, sufficiently fine to prevent the escape of the insects, but at the same time to give free access to the air. The frame-work of the roof is narrow but durable. A door is placed in one of the walls, large enough to give free access to the inside, that it may be conveniently arranged and kept in a state of cleanliness.

A great number of insects are aquatic in their habits, so that our insectarium must necessarily contain a reservoir of water, or an aquarium. But this need not be very large, in fact, it may be a lake in miniature. It should contain healthy water-plants. Its surface should be visible from above, and the flower-pots should be arranged on the stand in the insectarium, so that the light can be reflected from its surface. The water should therefore be kept in a handsome earthenware or porcelain bowl. A selection of appropriate insect larvæ may be placed on the leaves of the plants in the aquarium, as represented in the engraving.

The ground of the insectarium must consist of mould, thoroughly sifted, to free it from worms and stones, and mixed with sand. Fine grass seed may then be sown, and moss planted in it. Pots of plants, which are to serve as food for the caterpillars, and the flowers of which are to supply the bees and butterflies with honey and pollen, must be sunk in the soil, so that they may feel as much at home and as comfortable in their confinement as if they were on the slope of a mountain amongst the thistles and birches. The butterflies will flutter about the insectarium, and then settle on the flower-stands amongst the pots, displaying their colours in the light. Sweet sap may be offered them, in which they will plunge their proboscis; and for awhile we may thus enjoy their splendour, until the fluttering of their wings has removed the light scales, too easily rubbed off, to which the brilliancy of their colours is chiefly due.

Upon the large hand-divided leaf of the castor-oil plant, seen in the picture, there is a large caterpillar eagerly devouring it. If unchecked, a brood of caterpillars would soon become a curse in the insectarium, for they would destroy the flowers in an hour, and we

should only have a glass case with a wilderness of leafless stems and branches. If we wish to breed caterpillars in the insectarium we must prevent such destruction. But this can only be done by imitating nature, which employs agents to restrain the excessive productiveness of the caterpillar. In nature the caterpillar is not a curse but a blessing, for it furnishes an abundance of healthy, nutritious food for swarms of insectivorous birds, as well as beetles, such as the red-spotted caterpillar-hunter (*Caloroma calidum*). The breeding of caterpillars in the insectarium must therefore be under firm control; the insectarium must undergo daily revision, and the voracity of the larvæ must be kept in check.

Caterpillar Breeding in the Insectarium.

In the chapter on "Caterpillar Breeding," we have already said something with reference to the breeding of butterflies; we shall now enter more fully into detail, to meet the requirements of the insectarium.

It is quite impossible to put roots of the food-plants of our caterpillars into flower-pots, and place them in the insectarium. We can also only introduce one or two caterpillars, otherwise our plants will soon be devoured, and we shall have to begin again. If we have many caterpillars, they will distribute themselves with eager voracity over the whole place, while others will suffer hunger rather than disturb a leaf which is not their proper food. Besides, it is usually the leaves of trees which our caterpillars require, and these cannot be transplanted into the insectarium. Those who wish to secure butterflies merely for their collections should purchase them at the insect dealers, or of those who make the science a business. If the object is to study the life of butterflies in its different stages, the growth of the caterpillar, its different changes of skin and colour, its transformation into a chrysalis, and at last to observe the creeping out of the winged insect, and the first movements of its new life, it becomes necessary to provide the caterpillars with suitable food-plants, which should be renewed daily if possible. Where it is difficult to obtain them, withering may be prevented by keeping them in glasses of fresh water, so that there may be no interruption to the

feeding of the caterpillars. Willow, poplar, cherry, blackberry, linden branches, nettles, and other plants, may be thus preserved fresh and green, and should be regularly and carefully renewed.

There is just the possibility of breeding foreign butterflies in the insectarium, provided the difficulty can be overcome with reference to the foreign food-plants. We should then have the pleasure of seeing some of the magnificent butterflies of warm climates issue from their chrysalis or cocoon in all their fresh and brilliant beauty. The experiment has been already successfully tried, and several species of large foreign silkworm moths have been bred from their caterpillars, and the silk obtained from their cocoons.

We will now make some few remarks on the hablts of caterpillars, their change of skin, and their transformation into chrysalids. Previous to becoming chrysalids, caterpillars generally change colour, cease to eat, and ultimately to move; they then spin fine silk threads drawn out of the under lip, and not, as in spiders, through openings in the hinder parts, called spinnerets; in the midst of these threads they suspend themselves, continually twisting the body, now contracted into a chrysalis, until they are enwrapped with a thick silken cocoon. When complete, these cocoons may be packed in a box, preserved in moist sand, and sent to a distance. They may also be placed in the insectarium, when, at the proper season, the butterfly will creep out of them. Others spin only a pair of threads, and by their means draw two leaves together, so as to form a sort of sheath or case, in which the chrysalis places itself.

In such cases as these, the last skin is cast. The caterpillar skin being stripped off, the footless pupa becomes visible. Its horny coat of mail shows clearly the form of the eyes, antennæ, and wings belonging to the butterfly; it cannot eat, and only its hinder sections move, but they do this in a lively manner if seized. Boys make it move sometimes, in order to convince themselves that the pupa is alive; but it is better to let it alone, because the pressure of the finger hurts the insect. Generally there creeps out of a pupa which has been much fingered only a cripple of a butterfly.

Many caterpillars bury themselves in the earth, where they undergo their final transformation into pupæ. If we feed these in our

insectarium, as the time of their transformation approaches, they indicate their purpose of burying themselves by restlessness, and by a remarkable transformation of colour. We then do well to remove them from the insectarium, and place them in a separate box containing fine sand in which they can bury themselves. After about eight days we may cautiously look after them, and notice whether their transformation has been completed; if it has, we may dig up the pupæ carefully, and preserve them in moist sand till their hour is come. It would not do to leave such a pupa in the insectarium, where it would be liable to be disturbed by grasshoppers and beetles, if not devoured, and thus irregularly developed. But after the butterfly has crept out of its chrysalis it may be put in the insectarium. Many pupæ, as those of the diurnal butterflies, are left freely suspended; these can be safely trusted and left in the insectarium.

All insects do not pass through their changes of life in such well-defined order as the butterfly, the beetle, bees, and two-winged flies, whose changes (metamorphosis) we therefore call perfect. Crickets, dragon-flies, and bugs are not very different in their larval condition from the fully developed insect, for they gradually, and without any resting in the pupa condition, go through their successive stages of transformation,—called in this instance "imperfect metamorphosis."

"What a pleasure it is," says Professor Werner, "to observe the resurrection of a butterfly to life and freedom! From boyhood I wished to know how butterflies lived; how their caterpillars grew and changed their skin; how they became pupæ: I fed the caterpillars carefully, looked after their pupæ, and watched for the important moment when they would rupture their envelopes, and the butterflies appear. But, instead of this, a long-legged, fat, wingless body was produced. Surely it was a cripple I had so carefully educated! Besides, I had uselessly expended many weeks of care. This crippled insect, however, crept up the plant stem, leaving red drops on its pathway. There it remained sitting, gradually spreading out and moving the short stumps of its wings. I knew then that the creature was a swallow-tailed butterfly (*Papilio*), but its wings were now scarcely the twelfth part of an inch in breadth, thick, and com-

pressed into a small space. Continuing to sit in the same place, the creature soon reached its proper size; but the wings were still soft and limp, and not as yet in a condition to serve as sails in the atmosphere. But after a while it clapped them together for the first time, and I stood almost breathless over the newly-born insect, and rejoiced over the natural wonder revealed before me.

"I shall never forget," adds the Professor, "the impression that this spectacle produced upon me in childhood. 'See!' said my mother, who was with me at the time, and enjoyed the same wonderful and beautiful sight, 'it reminds us of a resurrection from the grave and the commencement of a new life.'"

How to Preserve Butterflies in the Insectarium.

Butterflies bred from pupæ in the insectarium can be preserved for a long time, if they are fed with sugary sap or cut fruit, or such-like material. This method is employed by butterfly hunters to effect their capture in the woods. The butterfly, when at large, invariably lays her eggs upon the proper food-plant of the future caterpillar; but in the insectarium, when this plant is not present, it will lay them on the glass frames, or any other convenient place.

Ichneumon Parasites.

It should not be forgotten that butterflies have their enemies, not only in the bird, but also in the insect world. One of the most deadly of these enemies, appointed to check the excessive multiplication of butterflies, is the ichneumon fly, belonging to the order Hymenoptera, to which the bee, wasp, and hornet belong. The ichneumon fly lays its eggs, by the help of an ovipositor, in the bodies of caterpillars of certain species. The larvæ which emerge from these eggs devour the fat body of the caterpillar, feeding on its inside, and thriving at its expense. In many cases the larvæ of the ichneumon are ripe before the caterpillar is transformed to a chrysalis. They then bore themselves through the skin of the caterpillar, and become pupæ on the outside of its body. Our readers may have seen cabbage caterpillars, which, instead of becoming pupæ, give birth to troops of small flies, which come out

and cover the body of the caterpillar. In this instance the larvæ of the ichneumon parasite instinctively eat all the inside of the caterpillar without attacking any vital part, thus availing themselves of the supply of nutriment afforded by the caterpillar up to the last moment of its life. Sometimes the parasitism of the ichneumon fly is carried a stage farther, for the caterpillar goes on feeding itself and its parasites, and even changes into a chrysalis; the larvæ then become pupæ in its inside, and creep out as ichneumon flies.

These ichneumon flies are the most annoying of insects to butterfly collectors, on account of the destruction they effect amongst the carefully-hoarded chrysalids; but otherwise they are very useful in maintaining the equilibrium of nature; for they prevent an improper increase of insects belonging to different orders, by injuring their caterpillars, and by destroying beetles, perforating their elytra, or hard wing-covers, with their ovipositors, and thus laying in them the eggs of parasites which ultimately destroy them. The pine-moth (*Bombyx monocha*), so exceedingly destructive to the pine woods of Germany, is kept down more by ichneumon flies than by any artificial means hitherto invented by man.

Insects suitable for the Insectarium.

In the preservation of beetles for the insectarium, we must confine ourselves to certain individuals. The Carabi, or ground beetles, being carnivorous beetles, cannot be introduced, because they will destroy the other insects, however their habits may delight and instruct us. When, however, in our walks we find beetles on leaves and flowers, these may be brought home, and their habits may be observed for awhile. A pair of stag-beetles (*Lucanus cervus*), male and female, may be kept prisoners for some time in the insectarium without doing much injury. The great stag-antler-like consuming nippers of this giant of British beetles are by no means the fearful weapons which their size would indicate. We must go to the oak woods about midsummer-day to find them. There they sit on the stem, where the sap leaks out of the fissures of the bark, and in the evening they fly buzzing around the tree crown. The upper jaw of the female is devoid of the antler. She lays her eggs on the oak-

stem; out of these eggs larvæ imperceptibly pass. They feed on the rotten wood, but grow very slowly, and only reach maturity in five years, when they are not less than four inches long and a finger breadth in thickness. Each one is then transformed into a chrysalid, which envelopes itself in a solid cocoon of saw-dust, and developes in a quarter of a year to a beetle, which very wisely remains concealed, because its elytra, or wing-cases, do not possess at first that hardness which they afterwards acquire. The fully-formed insect only lives a few weeks, when the female lays her eggs and dies.

In our picture, the black fellow to the right, in the foreground, whose abdomen is turned up, represents a very interesting insect with very short elytra, or wing-covers, called Brachelytra (Greek, *βραχύς*, short, and *ἔλυτρον*, a wing-case). Our native species are only small and disagreeable-looking, mostly brown or black beetles; whilst in foreign countries they appear in most splendid metallic colours. They live mostly on the ground, under rotten matter and fungi, behind the bark of trees, and many of them in flowers. Their long-legged larvæ are very similar to developed beetles, without wings. They feed principally on living insects. It is questionable whether they should be introduced into the insectarium.

The insect sitting in the foreground of our picture, before the stag-beetle, with the long hinder limbs, belongs to the well-known grasshopper, or locust family, which feeds on plants, and is very destructive in fields and gardens. Our native grasshoppers, however, are as harmless as the migratory locust is hurtful. These leaping insects belong to the order Orthoptera, or straight-winged insects, whose parchment-like wings are covered with a network of small veins; the forewings or wing-covers are not folded, but straight; the tender, broad, hinder wings are folded together, fan-like, when at rest. We can preserve and observe them in our insectarium. We have already spoken of their imperfect metamorphosis or change.

The field-cricket (*Gryllus campestris*) has only short antennæ; the leaf-cricket, or locust, on the contrary,—as, for instance, the great green grasshopper (*Gryllus viridissimus*), common in woods and fields,—has long, bristle-formed, feelers; and the female is distinguished by a long projecting ovipositor.

These grasshoppers enliven the insectarium, not only by their leaping about, but also by their music; contrasted with their performances, the dull buzz of the moth, and the hum of flies and bees, is poor and monotonous.

Everybody knows the unwearied chirp of the cricket in the meadows and bushes, but very few know that the cricket produces it by the friction of its hind-legs on its thick wing-covers. The depth of the tone is regulated by the size or strength of the wing-covers. The locust brings out clearer tones, but it is always the male who is the musician. The female enjoys and listens to the music of his serenade, but makes no reply. The organ of hearing in these insects is not in the head, but in the legs, and in the field-cricket, on the side of the hind-legs.

Amongst this order of insects there is a very remarkable one, popularly known as the praying mantis (*Mantis religiosa*). The head of this insect is mounted on a long neck, and its first two legs are elongated into powerful raptorial organs, and used for the purpose of capturing and destroying those insects upon which it feeds. These insects frequent trees; and as their colour resembles that of the foliage, they often escape observation. When lying in wait for prey, they usually assume an attitude which has been mistaken by the inhabitants of the countries where they are found for that of prayer. In reality the position is that in which insects are most easily seized and destroyed by them. These insects are very voracious, and are certainly among the most wonderful creatures in Southern Europe, gradually approaching their prey unnoticed, because of their resemblance to the leaves, and suddenly seizing it with their powerful fore-legs. They will fight and destroy each other when confined together. Certainly, they cannot be allowed in the insectarium without greatly restricting their liberty, otherwise they would soon destroy all the insect stock.

A few words on water insects may now be added. There are numerous interesting water-beetles and water-bugs, whose mode of swimming and habits will afford much amusement and instruction. These are easily taken with a dip-net in the marshes and freshwater streams of the neighbourhood, and transferred to the little aquarium.

The larvæ of the dragon-fly (*Libellula*), day-fly (*Ephemera*), and the caddis-worms (*Phryganidæ*), may be obtained in early spring, and their remarkable metamorphoses and changes may thus be leisurely watched in the water.

We cannot proceed far in the practical study of animals in our aquarium, terrarium, and insectarium without seeing the necessity for skilfully maintaining the same wise arrangement and balance amongst the animals, which undeniably exists in nature, and which are most conducive to their health and comfort. In doing this we are really only imitating that supervision which God exercises over all the works of His hands. He has placed His creatures where it is best and happiest for them to be. One part of creation corresponds to another. Where there is appetite, there is food; where the faculty, there the material for enjoyment. Seeming exceptions there may be; but upon the whole we would heartily echo the words of Paley:

"It is a happy world after all. The air, the earth, the water teem with delighted existence. In a spring noon or a summer evening, on whichever side I turn my eyes, myriads of happy beings crowd upon my view. . . . The insect youth are on the wing. Swarms of new-born flies are trying their pinions in the air. Their sportive motions, their wanton mazes, their gratuitous activity, their continual change of place without use or purpose, testify their joy and the exultation which they feel in their lately discovered faculties. A bee amongst the flowers in spring is one of the most cheerful objects that can be looked upon. Its life appears to be all enjoyment; so busy and so pleased; yet it is only a specimen of insect life, with which, by reason of the animal being half domesticated, we happen to be better acquainted than we are with that of others. The whole winged insect tribe, it is probable, are equally intent upon their proper employments, and, under every variety of constitution, gratified, and perhaps equally gratified, by the offices which the Author of their nature has assigned to them. But the atmosphere is not the only scene of enjoyment for the insect race. Plants are covered with aphides, greedily sucking their juices, and constantly, as it should seem, in the act of sucking. It cannot be doubted but that this is

a state of gratification: what else should fix them so close to the operation and so long? Other species are running about with an alacrity in their motions which carries with it every mark of pleasure. Large patches of ground are sometimes half covered with these brisk and sprightly natures.

"If we look to what the waters produce, shoals of the fry of fish frequent the margins of rivers, of lakes, and of the sea itself. These are so happy that they know not what to do with themselves. Their attitudes, their vivacity, their leaps out of the water, their frolics in it —which I have noticed a thousand times with equal attention and amusement—all conduce to show their excess of spirits, and are simply the effects of that excess. Walking by the sea-side in a calm evening, upon a sandy shore and with an ebbing tide, I have frequently remarked the appearance of a dark cloud, or rather very thick mist, hanging over the edge of the water, to the height perhaps of half a yard, and of the breadth of two or three yards, stretching along the coast as far as the eye could reach, and always retiring with the water. When this cloud came to be examined, it proved to be nothing else than so much space filled with young shrimps in the act of bounding into the air from the shallow margin of the water, or from the wet sand. If any motion of a mute animal could express delight, it was this; if they had meant to make signs of their happiness, they could not have done it more intelligibly. Suppose, then, what I have no doubt of, each individual of this number to be in a state of positive enjoyment; what a sum, collectively, of gratification and pleasure have we here before our view!"

Let us never forget our higher calling, as being endued with reason and conscience. We may justly delight in the fulness, order, and varied interest of our collections from the realm of nature, mineral, vegetable, and animal; but there is still a realm beyond. He who "breathed into man's nostrils the breath of life," so that "man became a living soul," made that soul for Himself. It is the order of creation: the mineral for the vegetable, the vegetable for the animal, the animal for the spiritual, and the spiritual for GOD.

INDEX.

ABIES excelsa, 127
Abies pectinata, 127 [56
Abraxas grossulariata, 16,
Acer campestre, 132
Acer pseudo-platanus, 132
Aceraceæ, 96
Acetate of lead, 156
Acherontia atropos, 17, 54
Acheta campestris, 77
Acheta domestica, 76
Acilius, furrowed, 38
Acotyledons, 98
Acrocarpi, 105
Acrogens, 95, 98
Actinolite, 150
Aculeata, 64
Adamantine spar, 151
Adder's tongue fern, 101
Adiantum, 102
Adularia, 149 [132
Æsculus hippocastanum,
Agabus, two-spotted, 38
Agarici, 7, 120
Agaricus campestris, 120
Agaricus oreades, 120
Agate, 147
Agrion, 73
Alabaster, 152
Albite, 149
Alburnum, 124
Alder, 132
Alder buckthorn, 130
Algæ, 98, 116
Alisma plantago, 168
Alismaceæ, 97
Alum, 145
Alumina, 148
Alnus glutinosa, 132
Amaranthaceæ, 93, 97
Amaryllidaceæ, 97
Amber, 162
Amentaceæ, 97
Amethyst, 147
Ammophila, 65
Anacharis alsinastrum, 170
Anemone nemorosa, 85, 91
Angiospermia, 94, 96
Angiospora, 98
Angle-wings, 50
Anguis fragilis, 203
Animals suitable for aquarium, 172
Anobium tessellatum, 40
Anophytes, 95, 98
Anoura, 174, 176
Antennæ of beetles, 36
Anthracite, 161
Antimony, 158
Antimony glance, 158
Ants, 65
Apatura Iris, or Ilia, 16
Apaturidæ, 51
Apetalous flowers, 97
Aphides, 79
Aphodius, 5
Apidæ, 65
Apis mellifica, 67
Apis papaveris, 66
Apocynaceæ, 97
Apollo butterfly, 16, 213
Apple moss, 107
Apple tree, 131
Apples of Sodom, 64
Aquarium, animal life in,
 animals for, 172 [190
 at night, 191
 construction of, 165
 fish for, 172 [172
 fresh-water mollusca for,
 insects and larvæ for, 177
 management of, 189
 principles of, 165
 reptiles for, 172
Araceæ, 97
Arachnidæ, 80
Araliaceæ, 96
Arctia caja, 18
Argentiferous galena, 156
Argus butterfly, 29, 51
Argynnidæ, 50
Argynnis adippe, 17
Argynnis Paphia, 50, 213
Aristolochiaceæ, 97
Arrowhead, 169
Arum family, 97
Asbestos, 150
Ash, 128
Asilus, 70
Asparageæ, 97
Asparagus family, 97
Aspen, 133
Asphaltum, 162
Athericera, 71
Atlas moth, great, 48
Attagenus Pellio, 43
Augite, 149
Azure stone, 149

BABINGTON'S *Manual of British Botany*, 89
Back-swimmers, 79
Bacon beetle, 43
Badham's *Esculent Funguses of England*, 120
Balaninus nucum, 10, 45
Balsam family, 96
Balsaminaceæ, 96
Barberry family, 96
Barbula, 106
Bartramia pomiformis, 107
Baryta, 153
Basalt, 149
Batrachia, 174
Beard moss, 106, 114
Bee flies, 71
Beech, 130
Bees, 65
Beetle collection, 26
Beetle glasses, 3

Beetle, parts of a, 33
Beetle sieve, 11
Beetles, abdomen of, 34
antennæ of, 36
carnivorous, 37
changes of, 4
classification of, 37
claws of, 37
distribution of, 1
elytra of, 34
food of, 3
ground, 38
haunts of larvæ of, 2, 7
heads of, 33
labium of, 35
labrum of, 34
land, 37
legs of, 36
mandibles of, 35
maxillæ of, 35
mentum of, 35
mounting of, 27
net for catching, 4
palpi of, 35
setting out and mounting, 26
sieve for, 11
sketch of orders of, 33
sorts of, 37
spiracles of, 34
thorax of, 34
tin box for, 3
trachæ of, 34
water, 3, 38
Bentham's *Handbook of the British Flora*, 89
Berberidaceæ, 96
Beryl, 151
Betula alba, 133
Birch, 133
Bird cherry, 129
Birthwort family, 97
Bitumenised coal, 161
Black bryony family, 97
Blackjack of miners, 156
Blacklead, 161
Bladderwort family, 97
Blaps Mortisaga, 34, 43
Blende, 156
Blind-worm, 203
Blind-worms, skins of, 208
Blister beetle, 44
Blowpipe analysis, 142
Blue-bottle fly, 68
Blue butterflies, 17, 18, 51
Blue vitriol, 146
Bog iron ore, 154
Bog moss, 107, 161
Boleti, 7
Bombardier beetle, 9
Bombi, 67
Bombycidæ, 53, 54
Bombylidæ, 70
Bombyx monocha, 220
Bombyx mori, 16, 54
Boraginaceæ, 97
Borate of soda, 146
Borax, 146
Borers, 61
Bostrichus typographus, 46
Bot flies, 71
Botanist, outfit of, 84
Botany, synoptical view of natural system of, 96
Botany of the Northern United States, 108
Box-tree, 131
Boxes for mineral specimens, 140
Brachelytra, 39, 221
Brachinus crepitans, 9
Brake fern, 102
Bream, 173
Brimstone butterfly, 16
Brimstone moth, larvæ of, 25
Brittle snake, 203
Broad green lava, 118
Brookline, 169
Brook liverwort, 110
Broom moss, 105
Broom-rape family, 97
Brown coal, 161
Brown hæmatite iron ore, 154
Brown polype, 188
Bruchus pisi, 10, 45
Bryum argenteum, 109
Bryum cœspiticium, 109
Bryum lanatum, 109
Bryum pyriforme, 107
Buckthorn family, 96
Buckwheat family, 97
Bufo calamita, 201
Bufo vulgaris, 200
Bug, bed, 79, 182
Bunt, 119
Buprestidæ, 40
Burmeister, Dr., quoted, 49
Burnia cratægata, caterpillar of, 25
Butcher's broom, 101
Buttercup, 86, 91
Butterfly collection, 26
Butterfly, death-grip of, 13
first appearance of a, 21
in the shears, 13
Butterfly net, 13
Butterfly shears, 12, 13
Butterflies, 11
caterpillars of, 49
chrysalids of, 217
classification of, 49
eggs of, 18
in insectarium, 219
mode of capturing, 12
pupæ of, 14, 48, 217
setting-boards for, 28
setting out and mounting, 26
times for capturing, 12
Buxus sempervirens, 131

CABBAGE butterflies, 17, 52
Cabera pursaria, 25
Caddis fly, 74, 186
Caddis worms, 185, 223
Calamine, 153
Calandra granaria, 10, 45
Calcareous spar, 151
Calla æthiopica, 190
Callitriche verna, 168
Calosoma calidum, 34, 216
Caltha palustris, 91
Caltha radicans, 90
Calycifloræ, 93, 96
Calyptra of mosses, 105
Campanula family, 97
Campanulaceæ, 97
Cannel coal, 161
Cantharis vesicatoria, 44
Caprifoliaceæ, 93, 97
Capsella Bursa pastoris, 86
Carabi, 220
Carabidæ, 9, 38
Carabus auratus, 9

Carabus, mouth of a, 34
Carbonaceous minerals, 161
Carbonate of copper, 153
Carbonate of lead, 155
Carbonate of soda, 146
Carbonate of zinc, 153
Carbunculus, 151
Carnelian, 147
Carnivora, 37
Carp family, 173
Carpenter bee, 65
Carpenter, Dr., quoted, 61
Carpinus betulus, 132
Carpocapsa pomonella, 58
Carrageen moss, 117
Carrion beetles, 4, 43
Caryophyllaceæ, 96
Cassida viridis, 44
Cassididæ, 44
Castanea vesca, 128
Castor-oil plant, 215
Cat-tail family, 97
Catchweed, 44
Caterpillar box, construction of, 24 [216
Caterpillar breeding, 15,
Caterpillar collection, preparation of, 23
Caterpillar, evacuating contents of, 23
Caterpillar house, 18
construction of, 20
Caterpillar hunter, red-spotted, 34,
Caterpillar in test-tube, 23
Caterpillar rake, 19
Caterpillar skins, 24
Caterpillars, food-plants of, group of, 25 [15, 18
mode of killing, 23
nocturnal, 19
ravages of, 19
slug-shaped, 51
spine-bearing, 50
stuffed, 24
woodlouse-shaped, 51
worm-shaped, 52
Catharinea undulata, 105
Catkin-stemmed silver moss, 109
Catocala, 56
Celantes, 52
Celastraceæ, 93, 96
Cellulares, 104
Cerambyx heros, 46
Cerambyx moschata, 45
Cerasus lauro-cerasus, 14
Ceratophyllaceæ, 96 [169
Ceratophyllum demersum,
Cercopidæ, 79
Cerura vinula, 56
caterpillar of, 25
Ceruridæ, 56
Cetonia aurata, 42
Chalcedony, 147
Chameleon fly, 70
Characeæ, 111
Charæ, 111
Chelonia, 174, 176
Chenopodiaceæ, 97
Chestnut, cultivated, 128
Chloride of sodium, 144
Chlorospermeæ, 117
Chondrus crispus, 117
Chrysalids of butterflies, 217
Chrysomela betulæ, 45
Chrysomela populi, 45
Chrysomelidæ, 45
Chrysoprase, 147
Chub, 173
Churchyard beetle, 34, 43
Cicada Anglica, 79
Cicada septemdecem, 79
Cicadæ, 78
Cicindela campestris, 8
Cicindelidæ 8, 37
Cimex lectularius, 79, 182
Cinnabar, 156
Cistaceæ, 96
Cladonia pyridata, 114
Cladonia rangifernia, 113
Clavicornia, 43
Clay, 148
Clearwings, 54
Clearwings, bee-formed, 54
Clematis Vitalba, 91
Climacium dendroides, 107
Clouded yellow butterfly, 52
Club mosses, 98, 102 [52
Coal, 161
Cobalt glance, 159
Coccinella, 8
Coccinella septempunctata,
Coccinellidæ, 46 [46
Cochineal insects, 79
Cockchafer, common, 27, 42
Codling moth, 17, 58
Colchicaceæ, 97
Colchicum family, 97
Coleoptera, 1, 178
outline sketch of, 33
Colias hyale, 52
Collecting drawers, 31
Collecting net, 3
Colymbetes fuscus, 38
Combustible minerals, 161
Comma butterfly, 50
Compositæ, 91, 97
Concealers, 52
Confervæ, 117
Coniferæ, 94, 97, 127
Convolvulaceæ, 97
Copper, 159
Copper butterflies, 51
Copper glance, 157
Copper nickel cobalt, 159
Copper pyrites, 157
Copperas, 158
Cord moss, 107
Corn-weevil, 10, 45
Cornaceæ, 93, 96
Cornus sanguinea, 133
Corolliflorae, 93, 97
Coronella levis, 206
Corundum, 151
Corylus avellana, 133
Cossus, 54
Cowper quoted, 81
Crabbe quoted, 112
Crabronidæ, 65
Crane flies, 69
Crassulaceæ, 96
Cratægus oxyacantha, 131
Cricket, common, 76
Cross toad, 201
Crowberry family, 97
Crowfoot family, 91, 96
Crowfoot, bulbous, 91
Crowfoot, celery-leaved, 91
Crowfoot, creeping, 91
Crowfoot, floating water, 92

Crowfoot, upright meadow
Crowfoot, water, 91 [91
Cruciferæ, 91, 96
Cruelty, warnings against, 2, 14, 24
Cryptogamia, 96, 98, 99
Cryptogamous plants, 99
Cuckoo-spit, 79
Cucurbitaceæ, 96
Culex mosquito, 69
Culex pipiens, 69
Culicidæ, 69
Cup lichens, 114
Curculio imperialis, 46
Curculionidæ, 10
Curled pondweed, 169
Currant family, 96
Cursoria, 75
Cushion moss, 107
Cuspidates, 56
Cylindracei, 52
Cynipidæ, 64
Cynthia cardui, 16, 213
Cyperaceæ, 98
Cyprinus auratus, 172

DACE, 173
Daddy long-legs, 69
Day fly, larvæ of, 223
Death-watch beetle, 40
Death's-head moth, 17, 54
Dermestes lardarius, 43
Dermestidæ, 43
Detegentes, 50
Devil's coach-horse, 39
Diamond, 151
Diamond beetle, 46
Dicotyledons, 94, 96
Dicranum, 106
Dicranum scoparium, 105
Didymodon purpureum, 106
Dillenius quoted, 109
Diptera, 68
Dipsacaceæ, 97
Diurna, 49
Diving water-beetle, 38, 179
Dog violet, 18
Dogs-bane family, 97
Dog's-tooth spar, 151
Dogwood, 93, 96, 133
Dolomite, 152
Dorcus parallelipipedus, 43
Dorr beetle, 41
Dragon fly, 73
larvæ of, 186, 223
Drone fly, 72
Drosera longifolia, 171
Drosera rotundifolia, 171
Droseraceæ, 96
Dry method of analysis, 142
Dry rot, 7, 119
Dryade, 51
Duckweed, 97, 176 [51
Duke of Burgundy butterfly
Dung beetles, 5
Duramen, 124
Dust brand, 119
Dytiscidæ, 38
Dytiscus marginalis, 38, 179

EARTHY minerals, 146
Echium vulgare, 212
Eel, 173
Eel grass, 168
Elæagnaceæ, 97
Elateridæ, 6, 39
Elatinaceæ, 96
Elder, 133
Elm, 129
Emerald, 151
Emperor butterflies, 16, 51,
Emperor moth, 20 [21
emerging from pupa-case,
Empetraceæ, 97
Endogens, 95, 97
Entomophaga, 63
Ephemera, 74
larvæ of, 223
Epsom salts, 146
Equisetaceæ, 98, 100
Equisetaceæ, fossil, 103
Equisetum arvense, 100
Ericaceæ, 91, 97
Eristalis, 72
Erycinidæ, 51
Euonymus Europæus, 131
Euphorbiaceæ, 97
European globe flower, 91
Evening primrose family, 96
Exogens, 94, 96
Exposers, 50
Eyed hawk-moth, caterpillars of, 25

FAGUS sylvatica, 130
False acacia, 129
Feather mosses, 104, 108
Felspar, 148
Ferns, 98, 101
Ferns, fossil, 103
Field cricket, 77, 221
Figwort family, 97
Filices, 98, 101
Filices, fossil, 103
Fireflies, 39
Fissidens, 106
Flax family, 96
Flea beetle, 8
Flesh flies, 72
Flints, 147
Floating pondweed, 169
Flowering plants, 96
Flowerless plants, 98, 99
Fluate of lime, 152
Fluor spar, 152
Fools' gold, 158
Forget-me-not, 171
Fossil resin, 162
Frankeniaceæ, 96
Fraxinus excelsior, 128
Frog, common, 176
Frog-hoppers, 79
Frog's bit, 97, 170
Fucaceæ, 116
Fucus vesiculosus, 116
Fulgorina, 79
Funaria hygrometrica, 107
Fumariaceæ, 96
Fungi, 98, 118
Fur beetle, 43

GAD flies, 70
Galena, 156
Galium aparine, 44
Gall flies, 64
Galleria, 58
Gamma moth, 56 [187
Gammarus pulex aquaticus,
Garnet, 150
Garnet, white, 149
Gasterosteus aculeatus, 173
Gastropacha quercifolia, 17
Gelidium, 117

Gentianaceæ, 97
Geographical lichen, 112
Geometer caterpillar, 25
Geometers, 55
Geometridæ, 55
Geotrupes, 5
Geotrupes stercorarius, 41
Geraníaceæ, 96
German silver, 159
Ghost moth, 54
Glauber salt, 145
Glow-worms, 10, 40
Glumaceæ, 98
Gnats, 69
Goat moth, 54
Goerius olens, 39
Gold, 160 [190
Gold and silver fish, 172,
Golden beetles, 45
Goldsmith beetle, 9
Gonepteryx rhamni, 16
Gooseſoot family, 97
Gourd family, 96
Gracillaria, 117
Gracillaria tenax, 117
Gramineæ, 98
Grammatite, 150
Graphite, 161
Grass family, 98
Grass pink, 212
Grasshoppers, 76, 221
Gravel, 147 [to remove, 59
Grease in a collection, how
Greasy fritillary, 50
Green grasshopper, 221
Green lizard, 205
Green polype, 188
Green vitriol, 146
Greenstone, 149
Gregarious fritillaries, 50
Grey antimony, 158
Grey copper ore, 157
Grimmia pulvinata, 107
Grizzled skipper, 52
Grossulariaceæ, 96
Ground beetles, 9, 220
Gryllotalpa vulgaris, 77
Gryllus campestris, 221
Gryllus viridissimus, 76, 221
Gudgeon, 173
Gymnospermia, 94, 97
Gymnospora, 98
Gymnostomum, 106
Gypsum, 152
Gyrinus natator, 38, 180

Hair moss, 105, 109
Hair streaks, 51, 213
Half-winged insects, 78
Halorageaceæ, 96
Halteres, 68
Haltica, 8
Haltica Nemorum, 44
Halymenia palmata, 117
Hawk moths, 17, 53
 caterpillars of, 25
Hawthorn, 131
Hazel-nut, 133
Heath family, 91, 97
Heavy spar, 153
Hellebore, green, 91
Hemerobius, 74
Hemiptera, 78
Hepaticæ, 110
Hepialidæ, 54
Hepialus, 54
Hepialus humulus, 54
Herbarium, 82
 how to arrange, 89
Herschell, Sir J., quoted,
Hesperia malvæ, 52 [137
Hesperidæ, 52
Heterocera, 49
Heteromera, 43
Heteroptera, 79
Hipparchia, 17 [51
Hipparchia Hyperanthus,
Hippuris vulgaris, 169
Holly family, 97
Homoptera, 78
Honey bees, 67
Honeysuckle family, 93, 97
Hooker and Taylor's *British Jungermannia*, 111
Hooker's *British Mosses*, 90
Hornbeam, 132
Hornblende, 149
Hornet fly, 70
Hornets, 65
Hornwort, 96, 169
Horse chestnut, 132
Horseflesh ore, 157
Horsetails, 98, 100
Hortus siccus, 90
Hottonia palustris, 170
House cricket, 76
House flies, 68, 72
Humble bees, 67
Hycopodium powder, 24
Hydra fusca, 188
Hydra viridis, 188
Hydrocharidaceæ, 97 [170
Hydrocharis morsus-ranæ,
Hydrocorisæ, 181
Hydrocotyle vulgaris, 171
Hydrometra stagnorum, 182
Hydrometridæ, 80
Hydrophilus piceus, 38
Hydropterides, 98
Hydrus piceus, 192
Hyla arborea, 202
Hymenoptera, 61
Hymenoptera, aculeated, 64
Hypericaceæ, 96 [108
Hypnum cristacastrensis,
Hypnum proliferum, 109
Hypnum purum, 104
Hypnum rutabulum, 109
Hypnum Schreberi, 109
Hypnum splendens, 109

Ichneumon flies, 22, 62
 larvæ of, 22
Ichneumon parasites, 219
Ichneumonidæ, 62
Ilicineæ, 97
Infusoria, 189
Insect boxes, 31
Insect forceps, 31
Insect orders, sketch of, 60
Insect transformations, 183
Insectarium, 212
 construction and regulation of, 214
 insects suitable for, 220
Insects, naming of, 31
Introduction to Entomology quoted, 187
Iridaceæ, 97
Iron, 157
Iron glance, 154
Iron pyrites, 157
Ivy family, 96

JASMINACEÆ, 97
Juglans regia, 133
Juncaceæ, 97
[ed, 187
KIRBY and SPENCE quot-

LABIATÆ, 91, 97
Labradorite, 148
Lac insects, 79
Lace fly, 74
Lacerta agilis, 205
Lacerta muralis, 205
Lacerta ocellata, 205
Lacerta viridis, 205
Lacertæ, 193
Lady-bird, 8, 46
Lamellicornia, 40
Laminaria digitata, 117
Laminaria esculenta, 117
Laminaria saccharina, 117
Laminariaceæ, 117
Lampyridæ, 40
Lampyris noctiluca, 10
Lantern fly, 79
Lapis-lazuli, 149
Larix Europæa, 128
Larch, 128
Larva-house, 20
Laurel leaves, 14
Lazulite, 149
Lead, 155
Leadwort family, 97
Leaf-roller, caterpillar of, 25
Leaf-rollers, 17, 57
Leaf-woods, 128
Leapers, 76
Lecidea geographica, 112
Leeches, 194
Leguminosæ, 91, 96
Lemna, 176
Lemnaceæ, 97
Lentibulariaceæ, 97
Lepidarium, 59
Lepidium Smithii, 90
Lepidodendrons, fossil, 103
Lepidoptera, 48
scales of, 48
Lepidoptera diurnal, 49
Lepidoptera nocturnal, 52
Lepidoptera pedunculata, 53
Lepidoptera sessiliventrea, [53
Letter lichen, 112
Lettuce green lava, 118
Leucite, 149
Leucodon, 106
Leuwenhoeck quoted, 48
Libellula, 73
larvæ of, 223
Libellulidæ, larvæ of, 186
Lichens, 98, 111
Ligniperda, 54
Liliaceæ, 97
Limaciformes, 51
Lime, 151
Lime felspar, 148
Limenitis, 50
Limenitis Camilla, 50
Limnæa, 172
Linaceæ, 96
Linden family, 96
Linden, small-leaved, 132
Linnæus' *Flora Lapponica* quoted, 108
Lissotriton punctatus, 175
Litharge, 155
Liverworts, 98, 110
Lizard, common, 193, 205
Lizards, eggs of, 209
skins of, 208
Loadstone, 153
Locust family, 221
Locusta migratoria, 77
Longicornes, 45
Loose-neck, 80
Loosestrife family, 96
Loranthaceæ, 97
Loudon's *Encyclopædia of Plants*, 90, 115
Lucanidæ, 7, 41, 43
Lucanus cervus, 43, 220
Lycæna, 17, 51
Lycænidæ, 51
Lycopodiaceæ, 98, 102
Lycopodium clavatum, 103
Lycopodium powder, 103
Lythraceæ, 96

MADDEN family, 97
Magnesian limestone, 152
Magnetic iron ore, 153
Magnetic pyrites, 158
Magpie moth, 16, 56
Maiden hair fern, 102
Malachite, 153
Malvaceæ, 96
Manganese, 154
Mantidæ, 76
Mantis religiosa, 75, 222
Maple, 96, 132
Marbled white butterfly, 18
Marchantia polymorpha, 11
Mare's-tail, 169
Marsh marigold, 91
Mason bees, 65
May fly, 74
Meal-worm beetle, 43
Megachile, 66
Melanagria callithea, 18
Melanospermeæ, 116
Melasoma, 34, 43
Melitæa Artemis, 50
Melitæidæ, 50
Meloe Proscarabæus, 44
Melolontha vulgaris, 27, 42
Membrane-winged insects, [61
Mentha aquatica, 169
Metallic minerals, 153
Metals associated with oxygen, 153
Mezereum family, 97
Mica, 148
Mignonette family, 96
Mildew, 59, 119
Milkwort family, 96
Millepedes, 11
Milton quoted, 178
Mineral collection, 135
what it should contain, 139
Mineral kingdom, changes in the, 135
Minerals associated with arsenic, 159
Minerals, classification of, [144
colours of, 141
forms of, 141
hardness of, 141
Minerals, how to recognise, 140
specific gravity of, 142
Minnow, 173
Mint family, 91, 97

Mistletoe family, 97
Mites, 59
Mnium roseum, 105 [143
Moist method of analysis,
Mole cricket, 77
Mollusca, freshwater, 172
Monochlamydeæ, 93, 97
Monocotyledons, 97
Moonstone, 149
Morus alba, 54
Mosquito, 69
Mosses, 98, 104
 peristomes of, 106
 sporules of, 106
 teeth of, 105
Moths, 11, 52
 eggs of, 18
 haunts of, 12
 modes of capturing, 12
 mode of killing, 14
 pupæ of, 14
 times for capturing, 12
Mountain ash, 131
Mourning-cloak butterfly,
Mud wasps, 65 [17, 213
Mulberry tree, white, 54
Müller quoted, 108
Mundic, 157
Muriate of ammonia, 145
Musci, 104
Muscidæ, 72
Mushrooms, 7, 98, 118, 120
Musk beetle, 45
Mustard family, 91, 96
Myosotis palustris, 171
Myriophyllum verticilla-
Myriopodæ, 80 [tum, 170

NAIADACEÆ, 97
Natter-jack, 201 [196
Natural history, study of,
Neck beetle, 43
Necklace lizards, 205
Necrophori, 43
Needle-woods, 127
Nemeobius Lucina, 51
Nemocera, 69
Nepa cinerea, 181
Nerve-winged insects, 73
Nettle family, 97
Neuroptera, 73
Newman, Edward, quoted,
 50 [31
Newman's *British Moths*,
Newman's *Familiar Intro-*
 duction to the Study of
Nickel, 159 [*Insects*, 68
Nightshade family, 97
Nitrate of potash, 145
Noctuidæ, 56
Nocturna, 52
Nocturni, 53
Non-bituminous coal, 161
Norway spruce fir, 127
Notacantha, 70
Notonecta glaucus, 80, 182
Notonectidæ, 79
Nut-weevil 10, 45
Nymphæa alba, 171
Nymphæa lutea, 171
Nymphæaceæ, 96

OAK galls, 64
Oak-lappet moth, 17
Obsidian, 147
Œstri, 71
Oidium, 119
Oidium albicans, 119
Oil beetle, 44
Oleaster family, 97
Onagraceæ, 96
Oniscidæ, 11
Onisciformes, 51
Onyx, 147
Opal, 147
Operculum of mosses, 105
Ophidia, 174
Ophioglossum vulgatum,
 101
Orange-tip butterfly, 17
Orchidaceæ, 97
Orobanchaceæ, 97
Orthoptera, 74
Orthotrichum, 107
Oscillatoria, 118
Osmia, 65
Ostrich-feather moss, 108
Oyster green lava, 118
Oxalidaceæ, 96
Oxide of tin, 155

PAINTED lady butterfly, 213
Palmella cruenta, 118
Palmellaceæ, 118
Paludina, 172
Panorpa, 74
Papaveraceæ, 96
Papilio, 218
 chrysalis of, 184
Papilio Apollo, 16
Papilio Camilla, 16
Papilio machaon, 16, 52, 213
Papilionidæ, 52
Parmelia parietina, 112
Parmelia saxatilis, 113
Paronychiaceæ, 96
Parsley family, 91, 96
Pea family, 96
Pea-weevil, 10, 45
Peacock butterfly, 18, 212
Pear moss, 107
Pear tree, 130
Pearl lizard, 205
Peat, 161
Pebble moth, 56
Pelopæus, 65
Pennywort, 171
Pentamera, 37
Pentatomæ, 80
Pepper brand, 119
Peristome of mosses, 106
Peroxide of iron, 154
Petaloideæ, 97
Phanerogamia, 96
Phasmidæ, 75
Phryganea, 74
Phryganea grandis, 186
Phryganideæ, 185, 223
Phyllium siccifolium, 75
Phytophaga, 44
Pieridæ, 52
Pieris brassicæ, 52
Pike, 174
Pilewort, 91
Pine family, 97, 127
Pine moth, 220
Pink family, 96
Pinus cembra, 127
Pinus strobus, 127
Pinus sylvestris, 127
Pit coal, 161
Planorbis, 172
Plant bugs, 80

Plant collection, 82
Plant lice, 79
Plantaginaceæ, 93, 97
Plants, how to name, 89
Plants, pressing, drying, and mounting, 85
Plants suitable for aquarium, and where to find them, 168
Platina, 160
Platinium, 160
Pleurocarpi, 105
Plum, 129
Plumbaginaceæ, 97
Plumbago, 161
Plusia Gamma, 56
Polemoniaceæ, 97
Polygalaceæ, 96
Polygonaceæ, 97
Polyommati, 51
Polyommatus Argus, 29
Polyommatus Phlæas, 17
Polypetalous flowers, 96
Polypodium vulgare, 101
Polytrichum, 105
Polytrichum commune, 109
Pond lily, white, 171
Pond lily, yellow, 171
Pond snail, 191
Pondweed family, 97
Pontia brassicæ, 17
Pontia cardamines, 17
Poppy family, 96
Poppy upholsterer bee, 66
Populus alba, 133
Populus tremula, 133
Porphyra, 118
Portulacaceæ, 96
Potamageton crispa, 169
Potamageton natans, 169
Prædones, 64
Praying mantis, 75, 222
Primulaceæ, 97
Protococcus nivalis, 118
Prunus avium, 129
Prunus domestica, 129
Prunus padus, 130
Pteris aquilina, 102
Puccinia graminis, 119
Pudding stone, 147
Pulse family, 91
Pumice-stone, 147
Pupa chest, 21
Pupæ of butterflies, 217
Pure metals, 159
Purple emperor, 51
Purple hair-streak, 18
Purple lava, 118
Purple-toothed moss 106
Purslane family, 96
Puss moth, 56
 caterpillar of, 25
Pyralides, 56
Pyralis forficula, 56
Pyrus communis, 130
Pyrus malus, 131

QUARTZ, 146
Quercus infectoria, 64
Quercus robur, 128
Quicksilver, 159

RANA temporaria, 176
Ranunculaceæ, 91, 96
Ranunculus acris, 91 [169
Ranunculus aquatilis, 91,
Ranunculus bulbosus, 86, 91
Ranunculus ficaria, 91
Ranunculus fluitans, 92
Ranunculus hirsutus, 92
Ranunculus repens, 91
Ranunculus sceleratus, 91
Rapæ, 17
Réamur quoted, 66
Red admiral butterfly, 16, 17, 18
Red hæmatite iron ore, 154
Red oxide of copper, 154
Red oxide of lead, 155
Red rag, 119
Redhorns, 52
Reduvius, 80
Reindeer moss, 113
Religious reflections, 47, 72, 80, 121, 134, 138, 162, 177, 186, 195, 223
Reptiles, true, 206
Reptilia, harmless, 199
Resedaceæ, 96
Resinous minerals, 162
Restaceæ, 92, 97
Rhamnaceæ, 96
Rhamnus frangula, 130
Rhodospermeæ, 117
Rhodoceridæ, 52
Rhyncophora, 45
Ring snake, 206
Ringlet butterfly, 17, 18, 51
Roach, 173
Robinia pseudacacia, 129
Rock-rose family, 96
Rosaceæ, 91, 96
Rose chafer, 42
Rose-leaf-cutter bee, 66
Rose-star moss, 105
Rose quartz, 147
Rubiaceæ, 97
Ruby copper, 154
Runners, 75
Ruscus aculeatus, 101
Rush family, 97
Ruskin's *Modern Painters*, quotation from, 115
Rust, 119

SACRED beetle, 41
Sagittaria sagittifolia, 169
St. John's wort family, 96
Sal ammoniac, 145
Salicaceæ, 93
Saline minerals, 144
Salix alba, 133
Salamander, spotted earth,
Salamanders, 193 [199
 aquatic, 174
 land, 174, 175
Salamandra maculosa, 199
Salt, common, 144
Saltatoria, 76
Saltpetre, 145
Sambucus nigra, 133
Sandal wood family, 97
Sand, common, 147
Sand wasps, 65
Sandstone, 147
Santalaceæ, 97
Sapphire, 151
Sarcophaga, 72
Saturnia Atlas, 48
Saturnia pavonia, 20
Satyridæ, 51
Sauria, 174
Saw beetle, 46
Saw flies, 61

Saxifragaceæ, 96
Scabious butterfly, 50
Scales of Lepidoptera, 48
Scarabæidæ, 41
Scarabæus sacer, 6, 41
Scarlet under-wing moth, [56
Scavenger beetles, 5
Scorpion fly, 74
Scotch pine, 127
Scotch topaz, 147
Scrophulariaceæ, 97
Sea-heath family, 96
Sea-weed, 98, 116
Sedge family, 98
Selenite, 152
Serpentine, 150
Serricornia, 39
Sesia bombyliformis, 54
Sesia fuciformis, 54
Sesidæ, 54 [flies, 28
Setting-boards for butter-
Seventeen years' locust, 79
Sexton beetle, 4
Shard-borne beetle, 41
Shepherd's purse, 86
Silica, 146
Silkworm moths, 16, 54
Silkworm moth, changes
Silphidæ, 4 of, 23
Silver, 160
Silver fir, 127
Silver fritillary, 213
Silver glance, 156
Silver moss, 109
Silver poplar, 133
Silver-spotted fritillaries, 17, 50
Silver willow, 133
Silver-washed fritillary, 50
Skin-beetles, 43
Skippers, 52, 183
Slabs for mounting, 27
Slow-worm, footless, 203
Slug-shaped caterpillars, 51
Smith's *English Flora*, 90
Smooth newt, 175
Smooth snake, 206
Smut, 119
Snails, freshwater, 172
Snakes, 206
 eggs of, 209
Snakes, flesh of, 209
 food of, 208
 skins of, 207
 swimming of, 209
Social bees, 66
Social wasps, 65
Soda, 146
Solanaceæ, 97
Sorbus aria, 131
Sorbus aucuparia, 131
Spadicifloræ, 97
Specular iron, 154
Sphagnum, 107, 161
Sphagnum acutifolium, 108
Sphagnum obtusifolium, [107
Sphingidæ, 53
Sphinx, caterpillar of, 25
Sphinx convolvuli, 17
Sphinx Ligustri, 53 [of, 25
Sphinx ocellatus, caterpillar
Spiders, 80 [131
Spindle-tree family, 93, 96,
Spine-bearing caterpillars,
Spinigeri, 50 [50
Sporangia of mosses, 105
Sporules of mosses, 106
Spring beetles, 6, 39
Spurge family, 97
Suspensi, 50
Stag beetles, 7, 43, 220
Stag's-horn beetle, 43
Stephens' *British Coleoptera*, 31
Stone lichen, 113 [173
Stickleback, three-spined,
Sticklebacks, 191, 192
Stone oak, 128
Stone pine, 127
Stonecrop family, 96
Stoneworts, 98, 111
Straight-hair moss, 107
Straight-winged insects, 74
Stratiotes aloides, 170
Stratyomis chamæleon, 70
Succincti, 51
Sugar of lead, 156
Sulphate of alumina, 145
Sulphate of copper, 146
Sulphate of iron, 146
Sulphate of lime, 152
Sulphate of magnesia, 146
Sulphate of soda, 145
Sulphate of zinc, 146
Sulphur, 162
Sulphuret of antimony, 158
Sulphuret of iron, 157
Sulphuret of lead, 156
Sulphuret of mercury, 156
Sulphuret of silver, 156
Sulphuret of zinc, 156
Sundews, 96, 171
Swallow-tailed butterfly, 16, 52, 218
 chrysalis of, 184
Swifts, 54
Sycamore, 132
Syrphidæ, 71

TABANIDÆ, 70
Tailed batrachians, 174
Tailless batrachians, 176
Talc, 148
Tamaricaceæ, 96
Tameaceæ, 97
Tangle, 117
Tanystoma, 70
Tapering bag, 13
Taxus baccata, 127
Teasel family, 97
Teeth of mosses, 105
Tenebrio Molitor, 43
Tenebrionidæ, 43
Tenthredinidæ, 61
Terebrantia, 61
Terrarium, 196
 animals suitable for, 199
 instructions for formation of, 197
 winter quarters for tenants of, 210
Tetramera, 44
Thalamifloræ, 92, 96
Thallophytes, 95, 98
Thecla, 51, 213
Thecla quercus, 18
Thistle butterfly, 16, 17
Thymelæaceæ, 97
Tiger beetles, 8, 37
 larva of, 9
Tiger moth, 18
 changes of, 19
Tilia parvifolia, 132

Tiliaceæ, 96
Tin, 155
Tineæ, 58
Tinstone, 155
Tipulidæ, 69
Toad, 200
Toadstools, 7
Tools used for obtaining minerals and fossils, 139
Topaz, 151
Tortoise beetle, 44
Tortoise-shell butterfly, 18
Tortoises, 176
Tortrices, 57
Tortricidæ, 17
Tortrix, caterpillar of, 25
Tortrix vitana, 58
Tortula, 106
Tourmaline, 151
Trachelia, 43
Trap, 149
Travellers' joy, 91
Tree, how to recognise the wood of a, 123
Tree frogs, 202
Tree moss, 107
Tremolite, 150
Trimera, 46
Triton cristatus, 174
Trollius Europæus, 91
Tropidonotus natrix, 206
Tufted bryum, 109
Turnip fly, 44
Turquoise, 149
Two-winged insects, 68
Typhaceæ, 97
Typographer beetle, 46

ULMUS campestris, 129
Ulva lactuca, 118
Ulva latissima, 118
Umbelliferæ, 91, 96
Upholsterer bees, 66
Urodela, 174
Uredo caries, 119
Uredo rubigo, 119
Uredo segetum, 119
Urticaceæ, 97
Usnea, 114

VALERIANACEÆ, 97
Vallisneria spiralis, 168
Vanessa Atalanta, 16
Vanessa antiopa, 17, 213
Vanessa C-album, 50
Vanessa Io, 212
Vanessidæ, 50
Variegated copper ore, 157
Vasculares, 100
Velia currens, 183
Verbenaceæ, 97
Vermiformes, 52
Veronica anagallis, 169
Veronica beccabunga, 169
Vervain family, 97
Vespa, 65
Viola canina, 18
Violaceæ, 96
Viper, common, 206
Viper's bugloss, 212

WALKING-LEAF insects, 75
Walking-stick insects, 75
Wall lichen, 112
Wall lizard, 205
Wall-pepper, 212
Walnut tree, 133
Wasps, predaceous, 64
Water beetles, 178, 222
 large, 38, 92
 larvæ of, 194
Water boatman, 80, 182
Water cabinet, 177
Water-crowfoot, white, 169
Water ferns, 98
Water flea, 182, 187
Water-lily family, 96
Water measurers, 80, 182
Water milfoil, 96, 170
Water mint, 169
Water moth, 186
Water newt, great, 174
Water plantain, 97, 168
Water scorpion, 80, 181
Water soldier, 170
Water speedwell, 169
Water star-grass, 168
Water tigers, 180
Water violet, 170
Water woodlouse, 187
Water-wort family, 96
Weevils, 10, 45
Werner, Professor, quoted, 212, 218
Westwood's *British Butterflies*, 31
Weymouth pine, 127
Whirligig beetle, 38, 180
White admirals, 16, 50
White butterflies, 52
White lead, 155
White vitriol, 146
White wave, caterpillar of, [25
Whitethorn, 131
White-toothed moss, 106
Whitlow-wort family, 96
Wild cherry, 130
Willow family, 93
Willow herb, 212
Wire worms, 6, 40
Withered-leaf insect, 75
Withering's *British Botany*, 90
Woolly bear, 19
Woolly bryum, 109
Wood anemone, 85, 91
Wood collection, 122
Wood-eaters, 46
Wood-lice, 11
Woodlouse-shaped caterpillars, 51
Woodpecker, 3
Wood-sorrel family, 96
Wood wasps, 65
Wordsworth quoted, 2
Worm-shaped caterpillars, [52

Xylocopa, 65
Xylophaga, 46, 62

Yellow copper ore, 157
Yellow oxide of lead, 155
Yew, 127

ZEOLITE, 149

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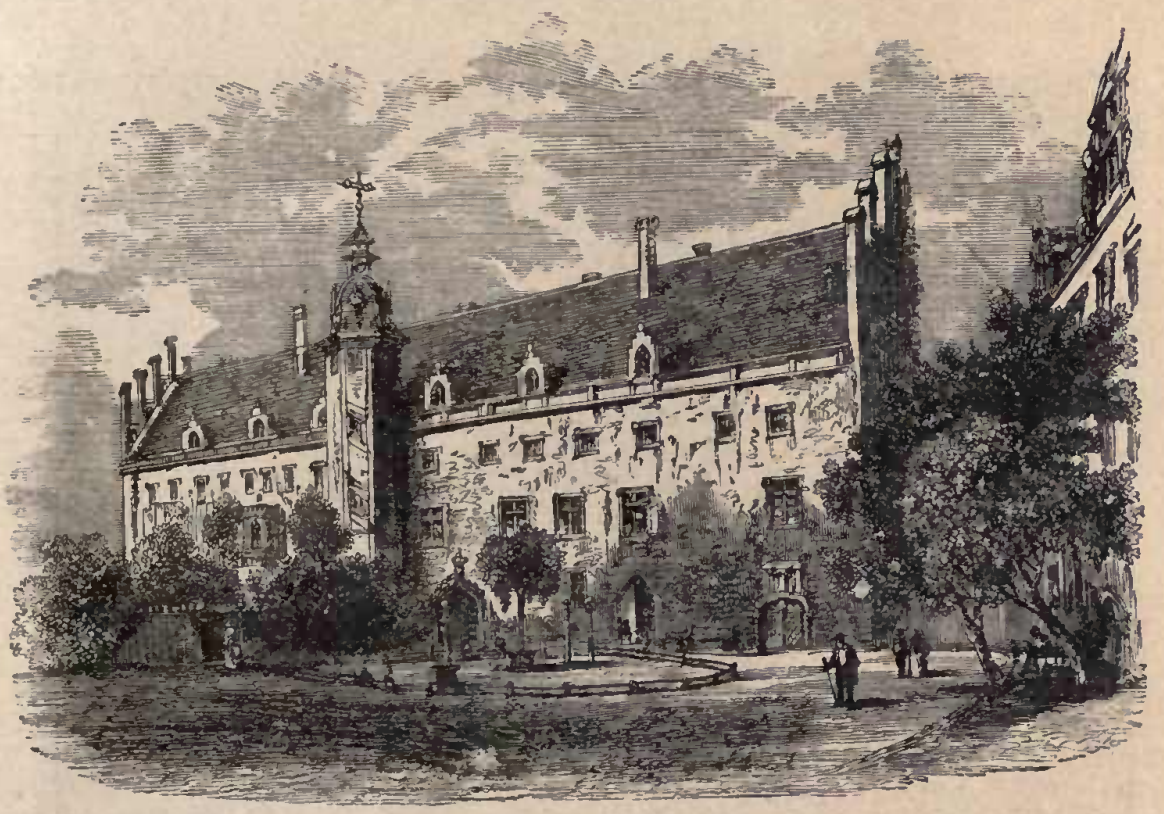
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